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ABSTRACT

The three papers in this report set forth the research methodology and the theory used in one research project to identify the processes involved in writing. The first paper proposes a method, termed protocol analysis, for use in identifying the organization of writing processes. It defines protocol analysis as a means for examining the detailed sequence of activities of a subject performing a task, shows how the technique can be used to identify writing processes, and describes some early research results obtained through its use. The second paper examines various hypotheses about the dynamics of writing and explores the constraints implicit in the writing task through a discussion of the knowledge, language, and rhetorical problems of one subject. The final paper presents an overview of the strategic decisions in investigating the writing process and summarizes the protocol analysis methodology. (FL)

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DESIGN PROJECT

Technical Report No. 1

A Process Model of Composition

Linda S. Flower
and
John R. Hayes

A product of the Document Design Project funded by the National Institute of Education, DHEW, Washington, D.C.

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Linda S. Flower and John R. Hayes

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ABOUT THE DOCUMENT DESIGN PROJECT

In September 1978, the American Institutes for Research, Carnegie-Mellon University and Siegel & Gale, Inc., began the Document Design Project to foster clear and simple writing and design of public documents. The purpose of the Document Design Project is to help make forms, regulations, brochures, and other written materials easier for people to read, to understand, and to use. Funding for the project comes from the Teaching and Learning/Reading and Language group at the National Institute of Education.

The Project's goal is to increase the knowledge and skills of people who produce public documents. To accomplish this goal, the Document Design Project is

- conducting theoretical and applied research studies on language comprehension, on the ways in which skilled and unskilled writers work, and on problems associated with different document features;
- working directly with government and private agencies as they produce materials for public use;
- developing courses on writing and design for graduate students and undergraduates.

This report is one of a series of technical and explanatory papers resulting from our research.

If you have questions or comments on this report or on other work of the Document Design Project, contact Dr. Janice C. Redish, Director, The Document Design Project, AIR, (202) 342-5071, or Dr. Lee W. Gregg, Department of Psychology, CMU, (412) 578-2781.

Preface

This report consists of three papers by John R. Hayes and Linda S. Flower. Some of the work was begun prior to the award of Contract NIE-400-78-0043. However, the ideas and observations were instrumental in the formulation of the CMU research plan. Moreover, data analyses and revisions of these papers were completed as a part of the current research on Document Design.

The first two papers were presented by Hayes and Flower at the Carnegie Symposium, "Cognitive Processes in Writing: An Interdisciplinary Approach" in May 1978. They will appear in an edited volume to be published late in 1979 or early 1980. The third paper was presented in April 1979 at the annual meeting of the American Educational Research Association in San Francisco, in a session on Recent Approaches to Writing Research. Some of the research was supported in part by Grant NIE-G-78-0195.

These papers set forth the methodology and the theory underlying our research on writing processes. Protocol analysis as explained in the first paper by Hayes and Flower is a method for examining the detailed sequence of activities of a subject performing a task, in this case a writing task. From the rich data source provided by the protocol, it is possible to draw inferences about the cognitive processes of writing. In this report, Hayes and Flower identify major components of the writing process--planning, generating, translating, and editing.

In the second paper Flower and Hayes examine various hypotheses about the dynamics of writing. The component

processes of writing are organized in complex ways. An important view of how writing actually progresses is presented in this paper. The writing process is driven by goals and subgoals of the plans formulated by writers to manage the many constraints implicit in the task--the task demands. Flower and Hayes discuss the nature of these constraints by examining the knowledge, language, and rhetorical problem of an individual subject.

If you can read only one of the papers (chapters) in this report, read the final one--Writing as Problem Solving. This paper presents an overview of the strategic decisions in investigating the writing process. The paper is an excellent summary of the method and theory adopted by Hayes and Flower.

I believe the theoretical framework provided by these papers and the protocol analysis methodology employed will take us a long way toward the design of writing models with the power and richness of human thought.

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Table of Contents

1. Identifying the Organization of Writing Processes 1

2. The Dynamics of Composing: Making Plans and Juggling Constraints 48

3. Writing as Problem Solving 84

1. Identifying the Organization of Writing Processes

John R. Hayes and Linda S. Flower

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Many have recognized that attention to process is potentially very important for the teaching of writing (Britton et al., 1975; Young et al., 1970). Unfortunately, relatively few researchers have actually studied writing processes experimentally. While noteworthy exceptions may be found in the work of Emig (1971), Zollner (1969), and Harding (1963), it is still true, as Britton et al. (1975) say, that "there has been very little systematic direct observation of fluent writers at work."

Cognitive psychologists have developed the technique of protocol analysis as a powerful tool for the identification of psychological processes (Newell and Simon, 1972). Although protocol analysis has most typically been used to identify processes in problem solving tasks, as we will see, it can be used to identify processes in writing as well.

In this paper, we will

1. describe the technique of protocol analysis[1];
2. show how it can be used to identify writing processes;

[1] For those who are unfamiliar with protocol analysis, we will describe it. For those who are familiar with protocol analysis but distrust it as a scientific method, we will try to allay some of their worries. Instructions to the reader to attempt or complete certain exercises are intended to help the reader understand the principles involved.

3. describe some early results in identifying writing processes which we obtained through its use.

What Is A Protocol?

A protocol is a description of the activities, ordered in time, which a subject engages in while performing a task.

A protocol, then, is a description, but not every description of a task performance is a protocol. Often we describe tasks mentioning only their outcomes or goals. We may say, for example, "My Great Dane, Spot, convinced me to give him his supper." This description tells us that the dog did one or more things to get food, but it doesn't say what these things were or in what order they occurred. That description, therefore, is not a protocol. The description below is a protocol, however.

Exp:	[seated at dinner table cutting into his steak]
Spot:	[seated directly behind the experimenter, his chin resting on the experimenter's shoulder. Spot watches intently as the steak is being cut.]
Exp:	[skewers a large piece of steak with his fork]
Spot:	[tail wags, stomach rumbles ominously]
Exp:	[begins to raise fork to mouth]
Spot:	[places paw on experimenter's arm and looks intently into experimenter's eyes]
Exp.:	"Spot!"
Spot:	[removes paw, continues to watch intently]
Spot:	[drools into experimenter's shirt pocket]
Exp.:	[abandons own dinner and feeds dog]

This is a protocol because it listed the activities which

Spot engaged in and the order in which they occurred. In the same way, when we collect protocols of people solving problems, we are interested not just in the answers they give us, but, also and more importantly, in the sequence of things they do to get those answers. For example, they may draw diagrams, make computations, ask questions, etc., and they do those things in a particular order.

Verbal Protocols

In a verbal, or "thinking aloud" protocol, subjects are asked to say aloud everything they think, everything that occurs to them, while performing the task, no matter how trivial it may seem. Even with such explicit instructions, however, subjects may forget and fall silent--completely absorbed in the task. At such times the experimenter will say, "Remember, tell me everything you are thinking." Figure 1-1 shows a typical thinking-aloud protocol for a subject solving a water jug problem.

Water jug problems require the subject to measure out a specified quantity of water using three jugs, as shown in Figure 1-2. None of the jugs has calibration marks. That is, there are no marks indicating a one quart level, a two quart level, etc. The subject is told only how much each jug will hold when it is full.

One typical water jug problem requires the subject to measure out 31 quarts when: jug A will hold 20 quarts; jug B, 59 quarts; and jug C, 4 quarts. The problem can be solved in four

Water Jug Problem: Given Jug A which contains 9 quarts; Jug B, 42 quarts; and Jug C, 6 quarts; measure out exactly 21 quarts.

Protocol:

1. Uh, the first thing that's apparent is half of B is, is the uh, the
2. amount that you want.
3. Exp: Uh huh.
4. Um, you can't get 21 from just multiplying up A or C.
5. You get 18 and 18 respectively, that's as close as you can get,
6. I guess. Um, so I'll try to think of the different combinations that
7. might . . . come up with a surplus . . . or deficit of the 21 quarts . . . and
8. 9 and 6 are, 15 . . . if you took two 9's and two 6's, you'd have 30 which
9. would leave you . . . and pour them into the 42 container, you'd have a,
10. an open space of a, 12, which means nothing. How about . . . see . . . now I'm
11. trying to think of how close to 42 you can get with a 9 and the 6 quantities.
12. You can get . . . I forget the 7 table. It's been a long time since I've
13. had to multiply or anything so you'll have to give me some time. Um,
14. 9 times 5 is 45 . . . hm, 6 times 7 is 42, I think. Is that right?
15. Exp: Uh huh.
16. OK, so you can, uh . . . fill B with C, evenly . . .
17. Exp: You could . . .
18. So . . . if you were to take . . . 36 . . . hm, oh, uh, 6 times 4 is 24, and if you, u
19. What I'm trying to get rid of is, is, 3 quarts there . . .
20. Exp: Good.
21. So if you were to, um . . . still 24. I, I was trying to think possibly,
22. some way of . . . the difference between the 6 and the 9 is 3 quarts. I
23. was trying to think of . . . a way to uh . . . oh, how about . . . you put the 3, 6
24. quart quantity into the 42 bottle, which is 18, then the runoff, from
25. pouring a 9 into a 6 which is 3 and 18 is 21.
26. Exp: Good.

Figure 1-1: Protocol of a water jug problem

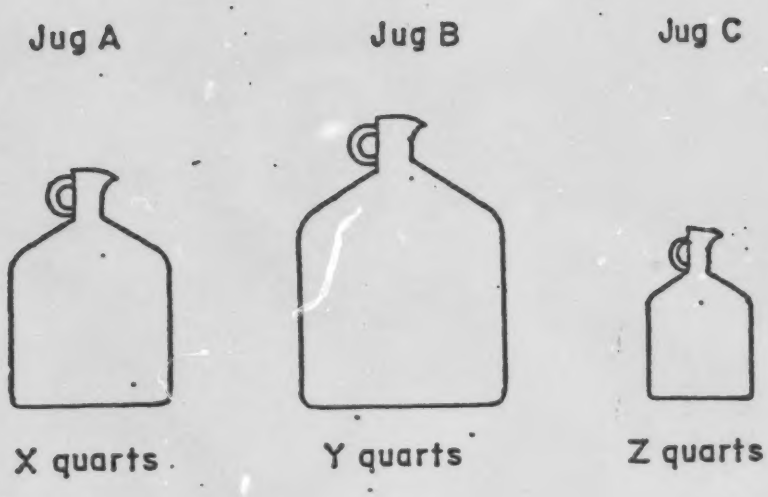

Figure 1-2: Non-calibrated jugs used to solve the water jug problem

steps as follows:

1. Fill Jug B.
2. Fill Jug A from Jug B, leaving 39 quarts in B.
3. Fill Jug C from B, leaving 35 quarts in B.
4. Empty C and fill it again from B, leaving the desired quantity, 31 quarts, in B.

It is helpful when you analyze a protocol to have done the task yourself beforehand. So, before beginning to analyze the protocol in Figure 1-1, try to solve the following problem.

> Meaure 100 quarts, given Jug A, holding 21 quarts, Jug B, holding 127 quarts, and Jug C, 3 quarts.

When you finish this problem, solve the problem in Figure 1-1 if you have not already done so.

An Example of Protocol Analysis

Now, let's examine the protocol in Figure 1-1 in detail and try to make some reasonable guesses about what the subject was doing.

In his first sentence, the subject mentions something which appears to be irrelevant to solving the problem. He mentions the fact that the desired amount (21 quarts) is just half the quantity contained in Jug B. Now, division is a very useful operation in many algebra problems. In this problem, if we could divide Jug B in half, the problem would be solved. But alas! There is no division operation in water jug problems. All we can do is add and subtract the quantities in Jugs A, B, and C. Why, then, does the subject notice that the desired quantity is half of B? The simplest answer seems to be that he is confusing water jug problems (perhaps because he isn't thoroughly familiar with them) with the more general class of algebra problems. If this answer is correct, we would expect that the subject would stop noticing division relations as he gains more experience with water jug problems. In fact, that is what happened.

On line 3, the experimenter (Exp.) does just what the experimenter is supposed to do--that is, he is non-committal. In general, the experimenter should answer only essential questions and remind the subject to keep talking.

From lines 4 and 5, we can guess that the subject has successively added 9's to get 9, 18, 27 . . . and 6's to get 6, 12, 18, 24 . . . and realized that neither sequence includes 21. From lines 6 through 10, we can see that the subject begins to consider combinations of 9's and 6's which may be added together to obtain interesting sums, or subtracted from the 42 quart container to obtain interesting differences. While considering sums, the subject fails to notice that the sum 6 + 6 + 9 solves the problem.

In lines 11 through 14, the subject tries to find out if 42 quarts can be obtained by adding 9's and 6's. The answer is "yes," but it doesn't help the subject to find a solution. It appears to be a "blind alley." In this section, the subject indicates several times that he doesn't feel confident about multiplication.

In lines 15 and 17, the experimenter provides the subject with a small amount of information by confirming his uneasy suspicion that 6 times 7 equals 42. On occasion, the experimenter must decide whether or not to provide information the subject requests. In this case, since the experimenter was really interested in water jug problems rather than in arithmetic, he decided to supply an arithmetic fact.

In lines 18 and 19, the subject realizes that if he had a way to subtract 3 quarts from 24 quarts, he could solve the problem. In line 20 the experimenter appears to slip by providing the subject with approval, when he would better have

	lines in protocol	operator applied	outcome	comment
forward search	1-2	divide by 2	fail	operator not available
	4-5	add 9's	fail	
	4-5	add 6's	fail	the subject apparently doesn't try all combinations because he fails to notice that 6 + 6 + 9 = 21
	6-8	add 9's and 6's	fail	
	7-10	add 9's and 6's and subtract from 42	fail	
means-ends analysis	18-19	notice difficulty	succeed	the subject notices the operators above got him no closer to 21 than 24; he sets the goal of finding an operator to subtract 3
	22	overflow 9 into 6	fail	
	23-25	add 6 three times and overflow 9 into 6	succeed	

Figure 1-3: Analysis of water jug protocol

formulates a goal on the basis of his difficulties in solving the problem. He notes that he hasn't been able to get closer than three quarts to the answer and attempts to find an operator that will subtract three quarts. This goal depends not just on the problem statement but also on the subject's experience in trying to solve the problem--that is, on his distance from the goal. It is a form of means-ends analysis in which the subject attempts to find a means to the end of reducing his distance from the goal.

The whole solution process then consists of:

1. an initial phase of forward search through an increasingly complex sequence of operators, followed by
2. a phase of means-ends analysis in which the subject succeeds in finding a solution.

In analyzing a protocol, we attempt to describe the psychological processes which a subject uses to perform a task. To do this, it is useful to be familiar both with the properties of the task and with the problem solver's component psychological processes. In analyzing the water jug protocol above, knowing that the task required algebraic operators and that human problem solvers often use processes of forward search and means-ends analysis helped us to recognize how the subject had organized these processes in his search for a solution. In the same way, when we analyze other protocols, knowledge of other tasks and of other psychological properties will be useful. This is not to say that we must already understand a performance before we can analyze it. It is just that when we do understand some things about the performance, we can use them very profitably to learn other things.

When we analyze the water jug protocol below, knowledge of the psychological phenomenon of set is very helpful. The problem used in this protocol can be solved in either of two ways. It can be solved by the procedure "B - A - 2C," or it can be solved by the simpler procedure "A - C." Just before solving this problem, the subject worked a series of six problems, all of which required the procedure "B - A - 2C" for solution. As a result, we would expect the subject to show a set to use the "B - A - 2C" procedure. As lines 6 through 9 show, however, the subject actually solves the problem by the "A - C" procedure. Nevertheless, if we look back to lines 3 and 4, we see that the subject's first problem solving attempt was to subtract A from B, which suggests that he started to use the "B - A - 2C" procedure even though he didn't carry it through. Clearly, analyzing the protocol gives us evidence about the subject's solution process that we can't get just by looking at the subject's answer.

Protocol Analysis--More Generally Considered

As we have seen, protocol analysis can be used as an aid in understanding a wide variety of tasks from simple problem solving in apes to complex performances such as chess playing in humans. Typically though, protocols are incomplete. Many processes occur during the performance of a task which the subject can't or doesn't report. The psychologist's task in analyzing a protocol is to take the incomplete record which the protocol provides together with his knowledge of the nature of the task and of human capabilities and to infer from these a model of the

1. Uh,..I'm adding and subtracting here.
2. Exp: Say what you're adding and subtracting.
3. O.K. Well, 23 from 49..is.r.uh...reminds me when
4. we keep score when we play cards. 26...oh, OK. Er it
5. would be easy enough. You take...um...OK. How do we
6. get this into water and jugs now?...because you could take a...
7. which is 23, and pour it into C which is 3, there we go,
8. pour it into C which is 3, and 20 would be what would go...
9. right into B.
10. Exp: Good.

Figure 1-4: A water jug protocol

underlying psychological processes by which the subject performs the task.

Analyzing a protocol is like following the tracks of a porpoise which occasionally reveals itself by breaking the surface of the sea. Its brief surfacings are like the glimpses which the protocol afford us of the underlying mental process. Between surfacings, the mental process, like the porpoise, runs deep and silent. Our task is to infer the course of the process from these brief traces.

The power of protocol analysis lies in the richness of its data. Even though protocols are typically incomplete, they provide us with much more information about processes by which tasks are performed than does simply examining the outcome of the process. Knowing what answer people get in solving problems is much less informative than catching even fragmentary glimpses of the complex processes by which they arrive at the answer.

Analysis of A Writing Protocol

In this section, we will first describe a model of expository writing. Then we will apply the model in analyzing a protocol by a writer who is especially clear in commenting about and identifying his writing processes. The degree to which the processes identified through protocol analysis correspond to the processes identified by the writer will provide a test of the model.

A Model of the Writing Process Derived Through Protocol Analysis

While space does not permit us to describe our research in detail, we have analyzed a number of writing protocols over the last two years. The results of this research have led us to propose the tentative model of the writing process diagrammed in Figure 1-5.

The Model

The unique features of the model are:

1. It identifies not only subprocesses of the composing process, but also the organization of those

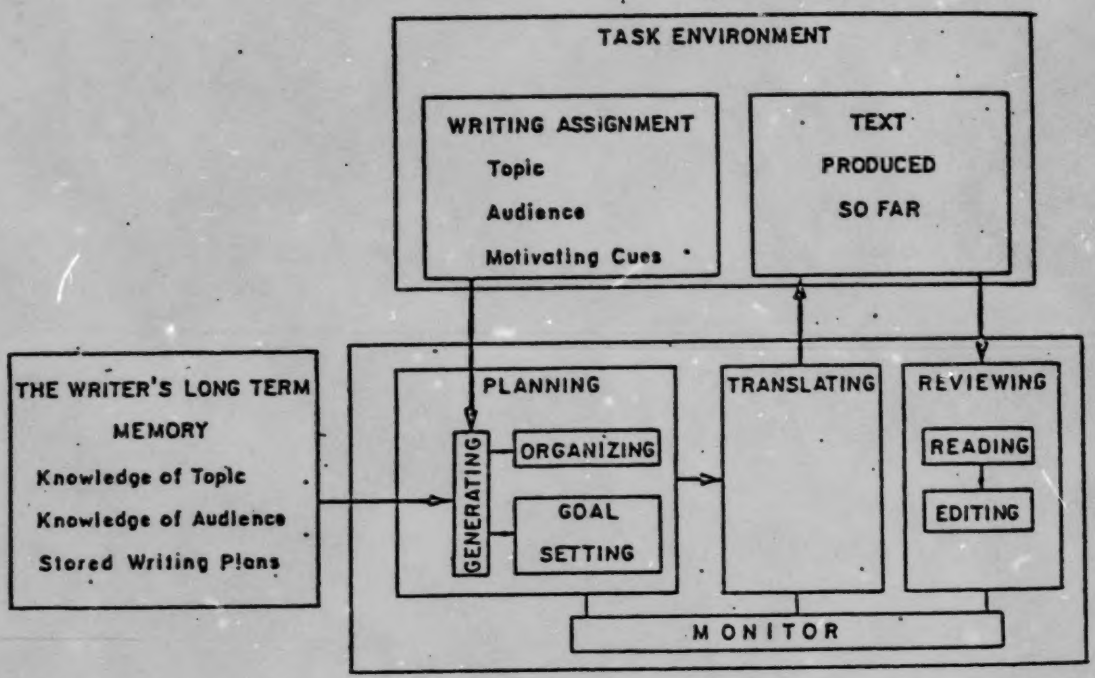

Figure 1-5: Structure of the writing model

subprocesses.

2. Minor variations in its simple control structure (shown in Figure 1-10) allow it to describe individual differences in composing styles.

While the model is provisional, it provides a first approximate description of normal composition which can guide research and afford a valuable starting point in the search for more refined models.

To facilitate our analysis of writing, we have divided the writer's world into three major parts: the task environment, the writer's long-term memory, and the writing process. Our model describes the writing process. The task environment and the writer's long-term memory are the context in which the model operates.

The Task Environment

The task environment includes everything outside the writer's skin which influences the performance of the task. It includes the writing assignment, that is, a description of the topic and the intended audience, and it may include information relevant to the writer's motivation. For example, the teacher's stern expression when he presents an assignment may tell the writer that the assignment must be taken very seriously. Britton et al. (1975) have emphasized the importance of such motivational factors. Once writing has begun, the task environment also includes the text which the writer has produced so far. This text is a very important part of the task environment because the writer refers to it repeatedly during the process of composition.

structures of the various processes are shown in Figures 1-6 through 1-10.

Planning: generating. The function of the GENERATING process is to retrieve information relevant to the writing task from long-term memory. We assume that this process derives its first memory probe from information about the topic and the audience presented in the task environment. Because each retrieved item is used as the new memory probe, items are retrieved from memory in associative chains. In order to focus search on relevant material, the retrieval chain is broken whenever an item is retrieved which is not useful to the writing task. Search is then restarted with a new memory probe derived from the task environment or from useful material already retrieved.

Some criterion for terminating search chains is essential to prevent the process from getting lost in associative reverie. The criterion which we have chosen, i.e., one irrelevant item, may have to be relaxed somewhat to simulate human performance accurately. We believe, though, that it won't have to be relaxed much beyond one item. The most persistent memory searches we have observed in writing protocols never extended more than three retrievals beyond useful material.

When an item is retrieved, the GENERATING process may produce a note. Characteristically, these notes are single words or sentence fragments, although they may sometimes be complete sentences. The form of these notes will be used later to identify occurrences of the GENERATING process.

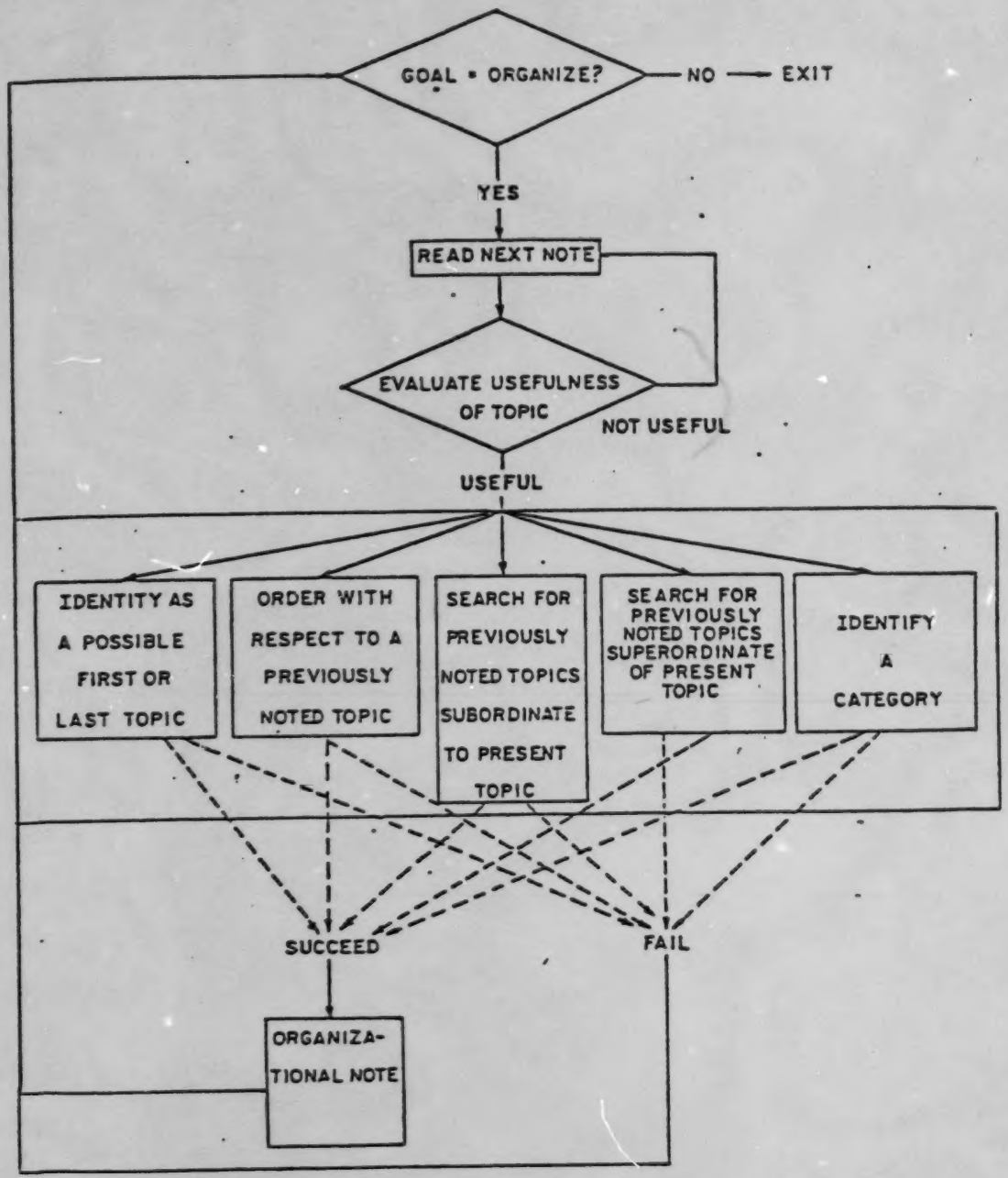

Figure 1-7: The structure of the ORGANIZING process

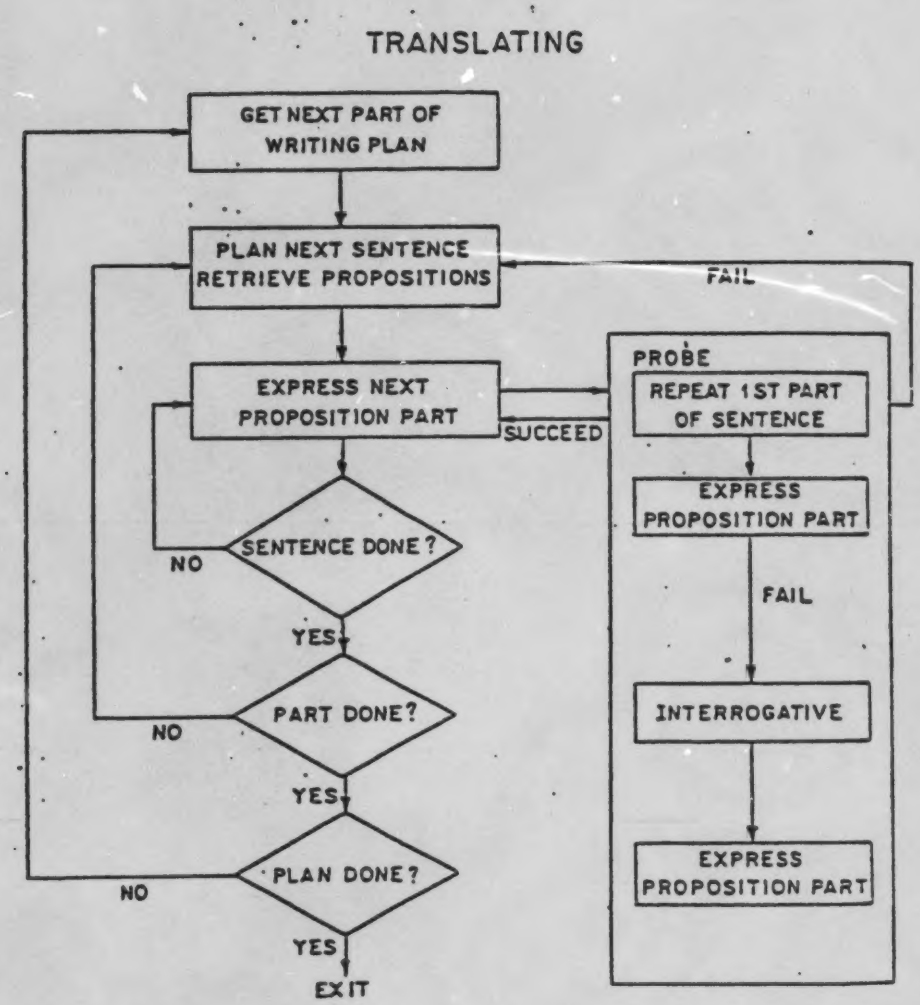

Figure 1-8: The structure of the TRANSLATING process

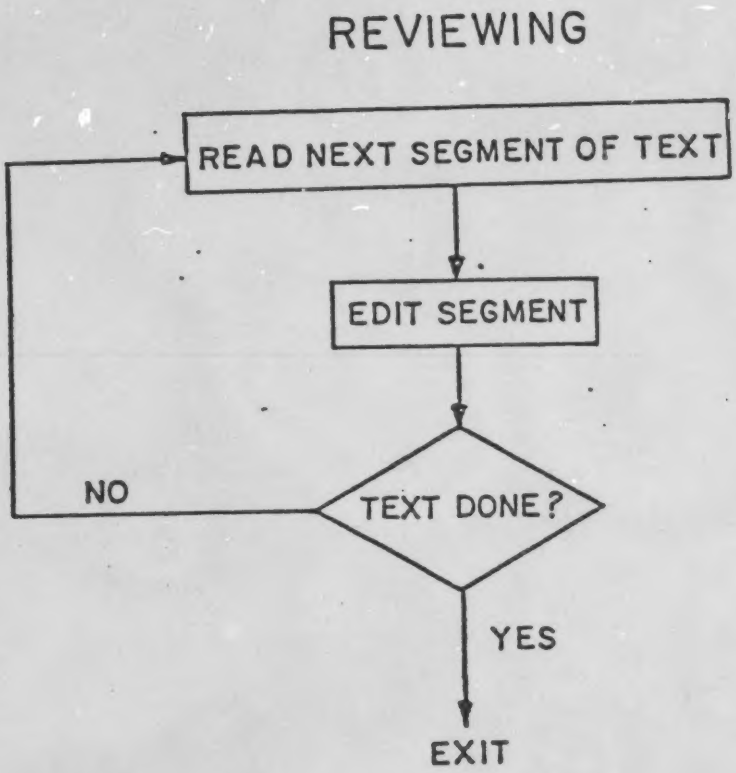

Figure 1-9: The structure of the REVIEWING process

EDITING

EDIT FOR STANDARD LANGUAGE CONVENTIONS

[(formal or note)(spelling fault) => fix spelling fault]

[(formal)(grammar fault) => fix grammar fault]

[(formal)(repetition of word) => search for alternative]

etc.

EDIT FOR ACCURACY OF MEANING

[(formal or note)(wrong word) => fix word]

[(formal or note)(ambiguous word) => remove ambiguity]

etc.

EVALUATE FOR READER UNDERSTANDING

[(formal)(unusual or technical word)=> find more common word]

[(formal)(missing context) => supply context]

etc.

EVALUATE FOR READER ACCEPTANCE

[(formal)(material offensive to reader)=> soften]

[(formal)(tone inconsistent) => make uniform]

etc.

Figure 1-10: The structure of the EDITING process showing alternative modes of editing

Planning: organizing. The function of the ORGANIZING process is to select the most useful of the materials retrieved by the GENERATING process and to organize them into a writing plan. The plan may be structured either temporally (e.g., "First, I'll say A, then B") or hierarchically (e.g., "Under topic #1, I should discuss A, B, and C") or both.

Organizing is done by the elementary operators shown in Figure 1-7. The first four of these operators act on single topics or pairs of topics; e.g., the second operator decides which of two topics to discuss first. The last operator, "Identify a category," may act to classify a large number of topics which were generated separately under the same heading.

Notes generated by the ORGANIZING process often have an organizational form. That is, they are systematically indented, or numbered, or alphabetized, or possibly all of these. This organizational form will be used later to identify ocurrences of the ORGANIZING process.

Planning: goal setting. Some of the materials retrieved by the GENERATING process are not topics to be written about but rather are criteria by which to judge the text. Often such criteria appear in the protocol when the writer is considering the audience or features of the text. At such times the writer may say, "Better keep it simple," or, "I need to write a transition here." The GOAL SETTING process identifies and stores such criteria for later use in EDITING.

Translating. The function of the TRANSLATING process is to

take material from memory under the guidance of the writing plan and to transform it into acceptable written English sentences. We assume that material in memory is stored as propositions but not necessarily as language. By a proposition, we understand a structure such as

[(Concept A) (Relation B) (Concept C)]

or

[(Concept D) (Attribute E)], etc.,

where concepts, relations, and attributes are memory structures, perhaps complex networks or images, for which the writer may or may not have names.

To illustrate the operation of the TRANSLATING process (see Figure 1-8), we have invented a scenario of a student writing an essay on Henri Rousseau.

1. Get next part of writing plan: "I've covered the early years, now I've got to say how he got into painting."
2. Plan next sentence: retrieve propositions.
   - Proposition A: [(Rousseau) (showed) (some early promise)]
   - Proposition B: [(Rousseau) (did) (very little painting until 40)]
   - Sentence plan: (Proposition A) but (Proposition B)
3. Express next proposition part: "Rousseau . . . Rousseau, what? Rousseau displayed . . . Although Rousseau displayed some early promise . . . etc."

Writing done during the TRANSLATING process shows two features:

1. Characteristically, it is in the form of complete sentences, and

2. It is often associated with a protocol segment which contains an interrogative reflecting search for the next sentence part, e.g., "Rousseau did what?" or, "How do I want to put this?"

These features will be used later to identify occurrences of the TRANSLATING process.

Reviewing. The function of the reviewing process is to improve the quality of the written text. It consists, as Figure 1-9 shows, of two subprocesses: READING and EDITING.

Reviewing: editing. The EDITING process examines any material which the writer puts into words, whether by reading, writing, or speaking. Its purpose is to detect and correct violations in writing conventions and inaccuracies of meaning and to evaluate materials with respect to the writing goals. These evaluations may be reflected in questions such as, "Will this argument be convincing?" and, "Have I covered all parts of the plan?"

We assume that the EDITING process has the form of a

production system.[1] The conditions of the productions have two parts. The first part specifies the kind of language to which the editing production applies, e.g., formal sentences, notes, etc. The second is a fault detector for such problems as grammatical errors, incorrect words, and missing context. When the conditions of a production are met, e.g., a grammatical error is found in a formal sentence, the action which is triggered is a procedure for fixing the fault.

Consider the following production:

[(formal sentence) (first letter of sentence lower case)
=> change first letter to upper case]

If the writer is producing formal sentences, this production will detect and correct errors in initial capitalization. However, if the writer is only producing notes, the conditions of the production will not be met and capitalization will be ignored.

While the action in the production above is simple, in some

---

[1] A production system is an ordered sequence of condition-action rules. The left side of each rule shows the condition or stimulus, and the right side the action to be taken if the condition is met. The conditions are tested in order, starting with the first rule. The order of the productions is important. Consider the production system for putting a horse in a barn:

Conditions	Actions
(horse out of barn) and (barn door closed)	(open barn door)
(horse out of barn)	(put horse in barn)
(barn door open)	(close barn door)

Changing the order of these productions could have very serious consequences for the horse!

cases the action may invoke the whole writing process recursively. For example, in one writing protocol, the writer's first draft contained the first sentence of the final draft immediately followed by the seventh sentence of the final draft. In editing the first draft, the writer recognized that the reader would not have sufficient context to understand the relation between these two sentences. To correct this fault, the writer constructed a small explanatory essay to insert between the sentences. Thus, in this case, the fixing procedure invoked the whole writing process.

We assume that the EDITING process is triggered automatically whenever the conditions of an editing production are satisfied, and that it will interrupt any other ongoing process.

We distinguish between REVIEWING and EDITING as two distinct modes of behavior. On the one hand, EDITING is triggered automatically and may occur in brief episodes interrupting other processes. REVIEWING, on the other hand, is not a spur-of-the-moment activity but rather one in which the writer decides to devote a period of time to systematic examination and improvement of the text. It occurs typically when the writer has finished a translation process rather than as an interruption to that process.

The monitor. The relations among the processes are defined by the simple production system shown in Figure 1-11. The

1. (Generated language in STM ——> edit)

2. (New information in STM ——> generate)

3. – 6. Goal setting productions (These vary from writer to writer; see Fig. Y.)

7. [(goal = generate) ——> generate]

8. [(goal = organize) ——> organize]

9. [(goal = translate)——> translate]

10. [(goal = review) ——> review]

Figure 1-11: Monitor

structure of the monitor was chosen to reflect three observations about the composition processes.

1. The EDITING and GENERATING processes may interrupt other processes. Thus, the first two production rules triggering EDITING and GENERATING processes take priority over goal setting rules.

2. The writer's intuitions and the persistence of his or her actions suggest that writing processes are controlled by goals. Thus, if writers report that they are trying to organize material, they will persistently return to ORGANIZING processes even when those processes are interrupted by EDITING and

GENERATING (productions 3 through 6 define the writer's goals).

3. Individual differences in goal setting reflect important individual differences in writing style. Figure 1-12 shows four alternative configurations for the goal setting productions. Each configuration corresponds to a characteristically different way of producing an essay. Configuration 1, for example, corresponds to a style in which the writer tries to produce a perfect first sentence and then to follow the perfect first sentence with a perfect second sentence and so on. The work of planning, translating, and reviewing each sentence is completed before the writer proceeds to the next sentence. With Configuration 2, thoughts are written down as they occur to the writer and he reviews later. With Configuration 3, the writer tries to generate a perfect first draft. Configuration 4 yields a breadth-first composing process. A draft is planned and then written out in full before any review takes place. Lowenthal and Wason (1977) have described writing styles among academics which correspond to Configurations 3 and 4.

Rules 7 through 10 in Figure 1-11 have the effect of executing the current goal when the goal activity is not being interrupted by rule 1 or rule 2.

As a final observation about the model, notice that the GENERATING process operates differently when the goal is GENERATING than when it is not. When the goal is GENERATING, the GENERATING process is persistent. That is, each attempt to generate is followed by another attempt to generate. When the

goal is not GENERATING, each attempt to generate is followed by a return to the process specified by the current goal (the one which GENERATING interrupted).

Testing the Model

We will compare our model with a writing protocol in which the writer gave especially clear indications of ongoing writing processes and of the transitions between processes. (The writer's style suggests that he sets his goals in the same way as the monitor with Configuration 4 [see Figure 1-12].) This relatively unambiguous protocol provides a rigorous test of the model's adequacy.

The protocol consisted of 14 pages of verbal transcript (the thinking aloud part of the protocol), five pages of notes, and a page of completed essay. We divided the verbal transcript into a sequence of segments, each containing a simple comment or statement. We have analyzed the first 458 segments of the transcript, or about half of it.

The segments are of three general types:

- Metacomments--comments which writers make about the writing process itself, e.g., "I'll just make a list of topics now," "I'm gonna write out a draft," "Better go back and read it over."

- Task-oriented or "content" statements--statements which reflect the application of writing processes to the current task, e.g., "That's not the right word" reflects an editing process; "I'll use that topic last" reflects an organizing process, etc.

- Interjections--such as "OK," "Well, let's see," "all right," "umm," "ah," etc.

Consider the sequence of segments: Well,/I'll just make a list

Configuration 1 (Depth first)

3. [New element from translate ⟶ (goal = review)]
4. [New element from organize ⟶ (goal = translate)]
5. [New element from generate ⟶ (goal = organize)]
6. [Not enough material ⟶ (goal = generate)]

Configuration 2 (Get it down as you think of it, then review)

3. [New element from generate ⟶ (goal = organize)]
4. [New element from organize ⟶ (goal = translate)]
5. [Not enough material ⟶ (goal = generate)]
6. [Enough material ⟶ (goal = review)]

Configuration 3 (Perfect first draft)

3. [Not enough material ⟶ (goal = generate)]
4. [Enough material, plan not complete ⟶ (goal = organize)]
5. [New element from translate ⟶ (goal = review)]
6. [Plan complete ⟶ (goal = translate)]

Configuration 4 (Breadth first)

3. [Not enough material ⟶ (goal = generate)]
4. [Enough material, plan not complete ⟶ (goal = organize)]
5. [Plan complete ⟶ (goal = translate)]
6. [Translation complete ⟶ (goal = review)]

Figure 1-12: Alternate configuration for the monitor

of topics now./Energy conservation,/pollution,/unemployment. The first segment is an interjection; the second, a metacomment; and the rest are task-oriented statements. (Interjections were not analyzed in this study.)

Writing protocols are complex and writers are often incomplete or ambiguous when they describe what they are doing. As a result, in analyzing a protocol, we frequently have to make judgments about the writer's meaning. The presence of such judgments may lead one to question the objectivity of the analyses. Since we are testing our model by comparing it to a protocol, we have to be especially careful to establish the objectivity of our analysis. To do this, we have taken the following steps:

1. Whenever objective evidence was available, we used it. Thus, reading and writing processes were identified by matching the verbal protocol word for word with the writer's notes and text (the objective evidence).

2. Whenever possible, processes were identified by using converging lines of evidence, e.g., the form of the written material, on the one hand, and the writer's comments about what he is doing on the other.

3. The most important analyses were replicated by independent judges.

Protocol Sections

The writer's metacomments suggest that the protocol can be divided quite cleanly into three sections. In the first section, including segments 1 through 116, the writer's goal is to generate; in the second, including segments 117 through 270, it is to organize; and in the third, including segments 271 through

458, it is to translate. Here are the metacomments which led us to this conclusion:

Segment 2. "And what I'll do now is to simply jot down random thoughts . . . ."

Segment 5. "Topics as they occur randomly are . . . ."

Segment 48. "Organizing nothing as yet."

Segment 69. "Other things to think about in this random search are . . . ."

Segment 117. "Now I think it's time to go back and read over the material and elaborate on its organization."

Segment 161. "Now this isn't the overall organization. This is just the organization of a subpart."

Segment 237. "There's an organization."

Segment 239. "Let's try and write something."

Segment 243. "Oh, no. We need more oganizing."

Segment 269. "I can imagine the possibility of an alternate plan . . . ."

Segment 271. "But let's build on this plan and see what happens with it."

If these assumptions about goals are correct, it follows from the model that the most frequent process in the first section will be generating interrupted occasionally by editing;

in the second, organizing interrupted by generating and editing; and in the third, translating interrupted by generating and editing. Further, we can make three predictions about the protocol:

1. The form of the written material should vary from section to section corresponding to changes in process from section to section. Thus, in the first section, we expect the generating process to produce many single words, detached phrases, and incomplete sentences. In the second section, we expect the organizing process to produce material which is systematically indented, alphabetized, or numbered. In the third section, we expect the translating process to produce many complete sentences and some material associated in the verbal protocol with interrogatives suggesting search for sentence continuation;

2. The content statements in the protocol should reflect the distribution of processes predicted above; and

3. The generating process should be more persistent in section 1 than in sections 2 and 3.

Hypothesis 1: The Form of the Written Materials

To test the first hypothesis, we wanted to determine if items written during the first section had a form consistent with the GENERATING process; items written during the second section, with the ORGANIZING process; and the items written during the third section, with the TRANSLATING process. For this purpose we identified all of the items written in the three protocol sections: 26 in the first section; 24 in the second; and 12 in the third. An item was a word, phrase, or sentence which was identifiable in the verbal protocol as being written during a single segment or several contiguous segments. It was, in effect, a short burst of writing.

Three raters were given the written material and verbal protocol and were asked independently to make the following judgments about each written item:

- Does it have good form, i.e., is it a complete, grammatical sentence?
- Is it part of a systematically indented, alphabetized, or numbered structure (i.e., does it appear to be part of an outline or structured plan of some sort?)
- Is it associated in the verbal protocol with an interrogative suggesting search for sentence completion?

Table 1-1 shows that there was excellent agreement among the raters in making these judgments. For each of the properties, Table 1-2 shows the proportion of items written during each section which were judged to have that property. An item was scored as having a property if two or more of the judges agreed that it did.

Items written during section 1 sometimes had good form but most usually had none of the three properties. Items written during section 2 typically showed the second property (indentation, etc.) but neither of the other properties. Two-thirds of the items written during section 3 were of good form and many were associated in the protocol with interrogatives. No items written in any other section were associated with an interrogative. These results are quite consistent with the view that GENERATING is the dominant process in section 1, ORGANIZING in section 2, and TRANSLATING in section 3, and thus provide strong support for Hypothesis 1.

Table 1-1

Agreement among Raters in Assigning Properties to Written Items

Agreement between Raters	Question A	Question B	Question C
1 & 2	.935	.968	1.000
1 & 3	.935	.984	.952
2 & 3	.903	.968	.952
Average Inter-rater Agreement	.924	.973	.968

Table 1-2

Proportion of Written Items with

Each Property

	Section 1	Section 2	Section 3
% good form	0.385	0.000	0.667
% indented, etc.	0.154	0.917	0.000
% interrogative	0.000	0.000	0.417

Hypothesis 2: Classifying "Content" Statements

Our second hypothesis is that the content statements in the protocol will reflect differences in distribution of processes in the three protocol sections. As with our first hypothesis, we are looking for evidence that the writing processes we have postulated turn up where they ought to, e.g., GENERATING should appear prominently when the writer says that his goal is to generate ideas, etc. In addition, we are looking for evidence that the EDITING and GENERATING processes interrupt the other processes as we have postulated. Again, the expected distribution of writing processes is, in the first section, GENERATING interrupted by EDITING; in the second, ORGANIZING interrupted by EDITING and GENERATING; and in the third,

TRANSLATING interrupted by EDITING and GENERATING.

To test this hypothesis, each of the authors independently classified each segment in two ways:

In classification 1, each segment was judged as belonging to one of the following four categories:

A. Interjections

B. Metacomments

C. Content statements

D. A combination of metacomments and content statements

In classification 2, the authors made judgments as to which of the writing processes was most likely to have given rise to the segment. Four alternative writing processes were considered: GENERATING, ORGANIZING, TRANSLATING, and EDITING.

Since the protocol sections were identified by examining the writer's metacomments, we wanted to test Hypothesis 2 using only segments which were purely content statements with no component of metacomment. Therefore, in the following analysis, we have considered only those segments which both authors classified as pure content statements. Out of a total of 458 segments, 170 were identified as pure content statements; approximately 130 as interjections; 18, previously identified as "reads," were not judged; and the remainder were judged by one author or the other as being metacomments in part or whole.

The authors agreed in attributing writing processes in 144 or 84.7% of the 170 content statements. Table 1-3 shows that, despite some differences, the authors agree that the content statements in section 1 can be attributed mostly to GENERATING; in section 2, to ORGANIZING; and in section 3, to TRANSLATING. They also agree that approximately 10 to 15% of the segments in each section can be attributed to EDITING and that approximately 10 to 15% of segments in sections 2 and 3 can be attributed to GENERATING.

Table 1-3

Proportion of Segments Assigned to Each Process

	Section 1		Section 2		Section 3	
	Author 1	Author 2	Author 1	Author 2	Author 1	Author 2
% GENERATING	79.5	86.4	18.3	15.0	13.6	7.6
% ORGANIZING	0.0	2.3	66.7	73.3	0.0	0.0
% TRANSLATING	11.4	0.0	5.0	0.0	72.7	77.3
% EDITING	9.1	11.4	10.0	11.7	13.6	15.2

The most important disagreement is that one author attributes some segments in sections 1 and 2 to TRANSLATING while the other does not.

Figure 1-13, which shows the processes author 2 attributed to the sequence of metacomments and content statements, illustrates two features of the protocol:

1. Interruptions of other processes by EDITING and GENERATING are frequent and widely distributed.

2. Even though in segment 117 the writer announced, "Now it's time to go back and read over the material and elaborate on its organization," apparently he doesn't do very much organizing until segment 153. The reason for this is that the writer is indeed reading (10 "reads" occurred in this interval), and the reading triggered some GENERATING and EDITING interrupts.

Since we made the judgments of process in the context of the whole protocol, one must be concerned that this context could have influenced our judgment. For example, we might have attributed a segment to GENERATING rather than to TRANSLATING if the segment occurred early in the protocol.

To determine if consistent judgments of process could be made without context, we conducted the following study. We selected 41 content statements from the protocol and typed them on cards. The cards were then shuffled and presented for judgment independently to two coders (not the authors). Coder 1 agreed with one of us in 67% of judgments and Coder 2, in 77% of judgments. Most of the disagreements (16 out of 22) involved judgments of EDITING. Many segments which the author attributed to EDITING the coders attributed to GENERATING. Since "edits" often present a comment on the previous segment or represent a change in a previous segment, EDITING may be especially difficult to identify out of context. It is difficult, for example, to see that segment 87, "I guess all elements are low level," indicates

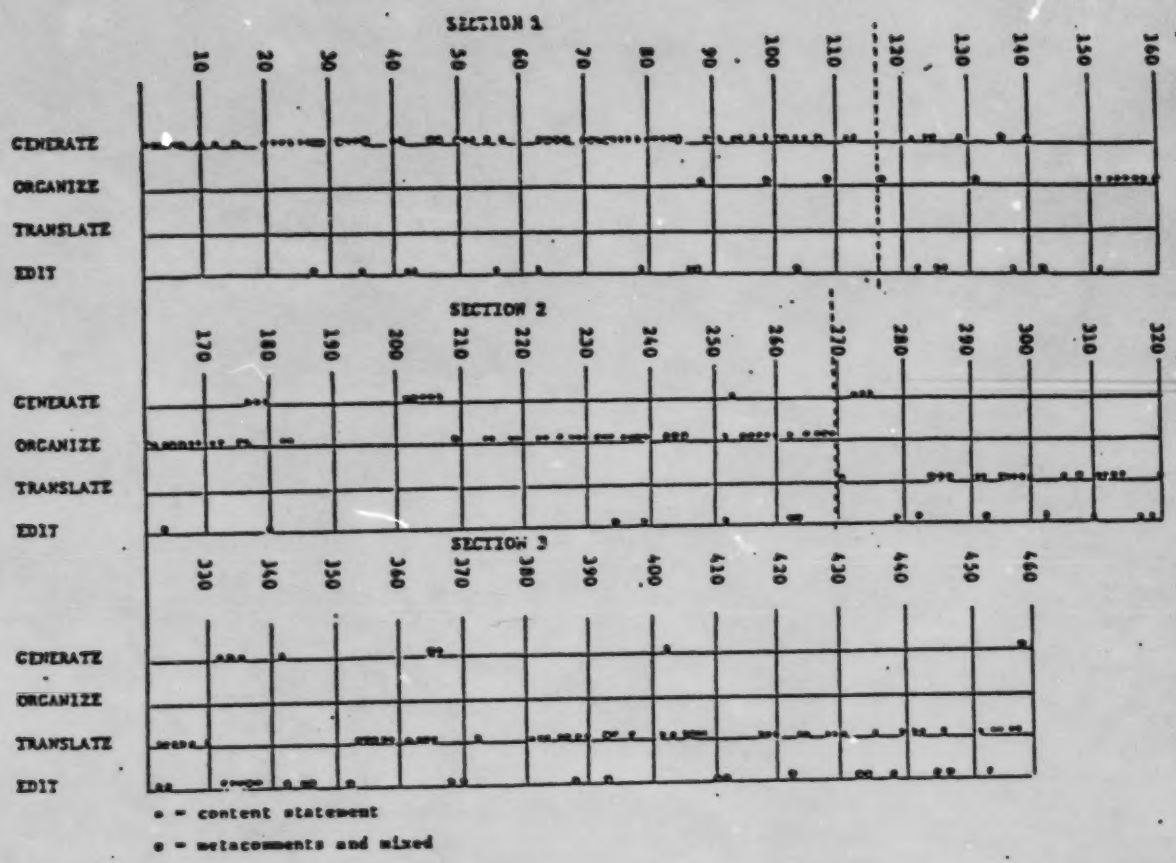

Figure 1-13: Processes attributed to segments by Author 2

editing for redundancy unless one also sees segment 86, "even low level elements of writing . . . ." If we consider only segments which the author attribted to GENERATING, ORGANIZING, or TRANSLATING, we find that both coders agree with the author in 86% of cases. These high levels of agreement are very encouraging and suggest that even if judgments were made without context, our conclusions concerning Hypothesis 2 would be substantially the same. Overall, then, our results strongly support Hypothesis 2.

Hypothesis 3: Measuring Retrieval Chains

Our third hypothesis is that the GENERATING process will be more persistent during section 1 of the protocol, when the goal is to generate, than during sections 2 and 3, when it is not. To test this hypothesis, one of the authors identified all of the content ideas generated during the protocol. (A single idea might be the topic of several protocol segments but was nonetheless counted as one idea.) A total of 48 separate ideas was identified. The two authors then independently judged whether each idea had been cued by the previous idea or not. Since the authors' judgments agreed in 96% of cases, we will simply present the average of their results.

In section 1, 32 ideas occurred in chains of average length 6.4, while in sections 2 and 3, 16 ideas occurred in chains of average length 2.0. As the model predicted, the GENERATING process was much more persistent during the first section of the protocol than during the second two. The fact that the average

chain length in sections 2 and 3 was two rather than one as the model requires suggests that our criteria for terminating search should be relaxed a bit.

Since the sequence in which ideas were retrieved in section 1 was strongly determined by associative connections, we might expect the same sequence and the same associative connections to appear in the final essay. We might expect this unless, of course, an active ORGANIZING process intervenes between GENERATING and TRANSLATING as the model postulates.

Figure 1-14 shows the writer's outline for the essay as a structure of ideas in tree form. The numbers in the figure indicate the order in which the ideas were generated. Clearly, the retrieval order is very different from the outline order.

Conclusions

We have described protocol analysis and have demonstrated that it can be a powerful tool for the analysis of writing processes. We should emphasize, however, that we recommend it as a research tool for use in the laboratory. It is far too laborious a procedure to be used routinely in the classroom, either for teaching or for evaluation.

We believe that the evidence provides very encouraging support for our model. All three of the model's predictions were strongly confirmed. We should note, however, that while these results are encouraging, they are quite limited in scope. First, while the model was derived through informal analysis of many

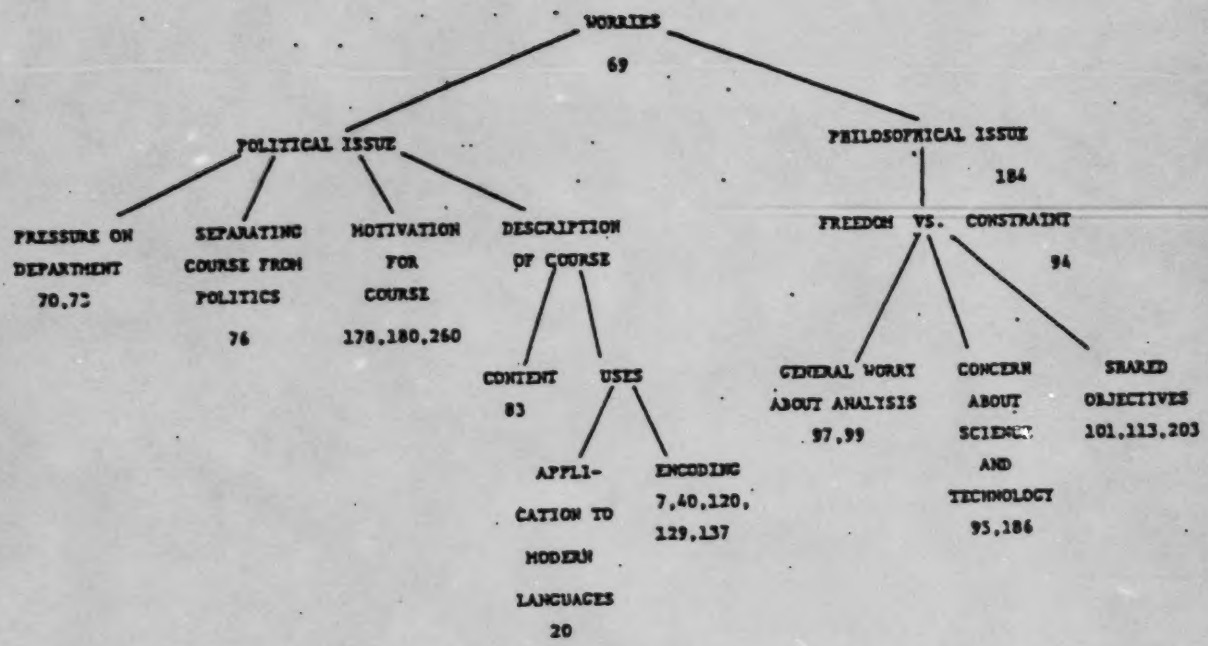

Figure 1-14: The writer's plan and the protocol segments in which the ideas were generated

protocols, it has been tested formally with only one protocol. Second, while the model is quite complex, only a few of its properties have been tested. We have tested some properties of the major writing processes, but we have not, for example, tested the model's predictions about individual differences nor about the structure of the editing processes. We plan to conduct much more extensive testing of the model in the near future.

Whether or not it is supported by the data, one may still ask, "Is there really anything new about the model? Haven't English teachers been talking about processes such as planning, organizing, and editing for a long time?" Indeed, English teachers <u>have</u> been talking about such processes for a long time. Nonetheless, there is a great deal that is new about the model. First, the model is rather specific about the nature of the individual processes (see Figures 1-6 to 1-10). Second, and more important, the model specifies the organization of these processes. In particular it specifies an organization which is goal directed and recursive, which allows for process interrupts, and which can account for individual differences.

We should caution the reader not to interpret our model as a stage model. We are <u>not</u> saying that writing proceeds in order through successive stages of PLANNING, TRANSLATING, and REVIEWING. It <u>may</u> do so, and, indeed, in the part of the protocol which we examined in this paper, writing did proceed generally in successive stages. However, this is not the only sort of writing behavior we have observed, nor is it the only sort allowed by the model. The model is recursive and allows for

a complex intermixing of stages. As we noted above, the whole writing process, including PLANNING, TRANSLATING, and REVIEWING, may appear as a part of an EDITING subprocess. Since EDITING can interrupt any other process, these processes can appear within any other process.

Further, we should note that we do not intend to imply that all writers use all of the processes we have described. Our model is a model of competent writers. Some writers, though perhaps to their disadvantage, may fail to use some of the processes. We have, for example, observed a writer who failed to organize. This writer, however, could not be viewed as competent.

We believe that our model, if it is approximately correct, can serve as a guide to the diagnosis of writing difficulties. We hope that, whether it is right or wrong, it can serve as "a target to shoot at," and hence a guide to further research on writing.

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2. The Dynamics of Composing: Making Plans and Juggling Constraints

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This paper is a response to an intriguing problem. Imagine yourself faced with the following situation. A person has just arrived on the doorstep saying, "I've never written anything before; teach me how to write." Suppose then that we happened to have a model of the composing process which said that in order to write, people must perform a number of mental operations: they must Plan, Generate knowledge, Translate it into speech, and Edit what they've written. These operations can draw on information stored in long-term memory and they go on within a Task Environment which includes both the task and a growing text. In other words we have a model very similar to the one proposed in our previous paper, "Identifying the Organization of the Writing Process" (Hayes and Flower, 1978).

Here then is the problem. Suppose we taught our would-be writer how to carry out each of the individual operations writers use (Planning, Generating, Translating, and Editing) just as we might teach a novice tennis player to serve, volley, and hit ground strokes. The question is, what happens when we ask our novice to put all of the pieces together, when we place our tennis player in the middle of an actual match? What happens when people--who have this set of independent subskills--actually try to write?

This paper attempts to use our proposed model of the writing process to describe writers in action. In other words, we would like to account, from the writer's point of view, for the dynamics of composing. We will be making two major points. The first is that the act of writing is best described as the act of juggling a number of simultaneous constraints. This is in contrast to seeing it as a series of discrete stages or steps that add up to a finished product. Secondly, we will suggest, one of the most effective strategies for handling this large number of constraints is Planning. Plans allow writers to reduce "cognitive strain," that is, to reduce the number of demands being made on conscious attention. They also create a nested set of goals which allow a number of constraints to be satisfied at once.

In exploring the dynamics of composing we hope to understand not only how people do it, but why they often find it difficult. This should in turn let us diagnose some of the problems writers encounter and suggest ways people can improve their own composing process. Let us turn first to the nature of this composing process.

Product-Based Models of Composing

There is of course a well established mythology about the nature of writing as a creative process. Some of this mythology is insightful; some of it pure bunk. Students often seem to subscribe to the inspiration paradigm in which a writer sits patiently waiting for delivery and the descent of the muse. For

example, one of our subjects had just finished a writing session that looked like a wrestle with the devil; yet when we asked her to describe the normal process of a good writer, she replied that this mythical writer would "just know exactly what she wants to say. She should just know what does she want to do, or he do, um, and just write it." This straightforward "think-it; say-it" model of the composing process does have a comforting simplicity. But when it is not plain wrong, it is rather useless because it tells us so little about what actually happens when people write.

An interesting contrast to the magical "think-it; say-it" model of composing is the "Pre-Write, Write, and Re-Write" model that has recently gained currency in many textbooks (Rohman, 1965). The critical assumption of Pre-Writing is that writing is a stage process; that is, the act of composition proceeds in a series of relatively discrete stages (Sommers, 1978). Pre-Writing is the stage, untouched by pen, paper, or rhetorical purpose, in which you discover your ideas. There are various avenues to this discovery. Depending on your instructor, they can range from library research, to sensory experience, to meditation and yoga. The great social value of the Pre-Writing notion is that it legitimizes thinking as a preliminary to immediate paper production. But as a model of the composing process, it still leaves the writer in the same bind; the task of writing is somehow separated from thinking, but still unexplained.

Stage process models have little to say about the act of writing itself because they are based not on a study of the

process of writing but the product. One suspects that they separate thinking and writing into separate stages because from the outside observer's point of view thinking and writing clearly differ: one mode creates a product while the other only produces troubled brows. And yet, the experience of writers rarely supports this tidy sequencing of stages. If we were to look at the composing process from the inside we would see that the tasks of planning, retrieving information, creating new ideas, producing language, and revising it all interact with one another throughout composing. A familiar example of this interaction is the way people often form their ideas through the act of putting them in writing.

A Metaphoric Process Model

If the stage process models, then, aren't convincing models of composing, is there a better way to describe the dynamics of this process? We know that when people write, they draw on a variety of mental operations such as making plans, retrieving ideas from memory, drawing inferences, creating concepts, developing an image of the reader, testing what they've written against that image, and so on. To produce any given utterance (which is to be simultaneously correct, effective, felicitous, and true) the writer must integrate a great number of these operations. The writer must exercise a number of skills and meet a number of demands--more or less all at once. As a dynamic process, writing is the act of dealing with an excessive number of simultaneous demands or constraints. Viewed this way, a writer in the act is a thinker on a full-time cognitive overload.

Let us translate this notion into a composing model.

When composition texts describe writing as a series of tidy sequential steps, the role of the writer is like that of a cook baking a cake or a CPA doing an income tax. The writer is advised to follow certain steps: select a topic, limit it, gather information, write it up, and then remove errors and add commas. Like the income tax procedure, this sequential process has rules or at least adages that govern the major steps, even if the act of writing is still somewhat unexplained.

The writers we have studied, however, give us a very different picture. A writer caught in the act looks much more like a very busy switchboard operator trying to juggle a number of demands on her attention and constraints on what she can do:

- She has two important calls on hold. (Don't forget that idea.)
- Four lights just started flashing. (They demand immediate attention or they'll be lost.)
- A party of five wants to be hooked up together. (They need to be connected somehow.)
- A party of two thinks they've been incorrectly connected. (Where do they go?)
- And throughout this complicated process of remembering, retrieving, and connecting, the operator's voice must project calmness, confidence, and complete control.

We use this switchboard operator as a metaphor to capture the dynamics of this process. Let us look now at the constraints themselves which we will discuss under three broad headings: Knowledge, Written Speech, and the Rhetorical Problem.

Constraints on Composing

To understand how constraints operate, it helps to imagine a relatively unconstrained situation--for example, one in which you could write by simply transcribing whatever comes to mind on the topic. Whether your task were to analyze family relations in Hamlet or to write a job application, in this unconstrained situation writing would be delightfully simple and whatever you said would get you an A+, an article in PMLA, or a new job at General Motors. By contrast when constraints enter the picture they affect the writer in two ways: first, a constraint is often a feature built into the writer's goal; therefore, any acceptable performance will have to exhibit this feature. Secondly, and as a result, such constraints actively shape the process of getting to a goal. For example, one of the constraints of a United Way memo is the need to be persuasive. To meet this goal, the writer might have to generate good arguments or subtle prods, organize sentences for effect, and constantly monitor the tone of voice she projects. Throughout the act of writing, the rhetorical purpose would be constraining the infinite variety of things she could say and, in the process, demanding a substantial amount of the writer's attention and effort. Therefore, constaints affect not only what people write but how they go about doing it. Constraints take up time.

In general, the constraints an adult writer must shoulder seem to fall into three major groups of increasing inclusiveness: the first constraint we will describe as the demand for

integrated knowledge; the second is the more inclusive linguistic conventions of written texts; and the third is the encompassing constraints of the rhetorical problem itself. Writing is like trying to work within government regulations from various agencies: whatever the writer chooses to say must, in principle, eventually conform to all of the constraints imposed from all of these areas. Let us look at each of these kinds of constraints in more detail.

Knowledge

Generally speaking, Knowledge is a resource, not a constraint. However, it becomes a constraint on the process when it is not in an acceptable form. In general, expository writing calls for relatively organized, conceptually integrated knowledge. When confronting a new or a complex issue, writers must often move from a rich array of unorganized, perhaps even contradictory perceptions, memories, and propositions to an integrated notion of just what it is they think about the topic. Some writers obviously go much further down this road than others, but much of the work of writing can be the task of transforming incoherent thought and loosely related pockets of information into a highly conceptualized and precisely related knowledge network.

In the protocol in Figure 2-1 we see a subject responding to the demand for sufficiently integrated knowledge. She has probably never had to talk, much less write, about her subject before, so her writing process is strongly constrained by the

need to formulate just what it is she thinks or knows. We will see her retrieving information from memory, drawing inferences, and relating her various ideas.

There are a number of important things to notice here. If we try to diagram the writer's developing knowledge structure as a map, we find that the topography keeps changing. The writer doesn't start with a well-formed thesis which she can just develop. Instead, she must juggle her ideas around trying to decide just how they are related. "Grades" is an interesting floater. Notice how it moves about on her knowledge map.

The arrows in Figure 2-2 indicate a general causal relationship between two ideas. If that relationship becomes further specified the line then receives a label as in episode 3. Initially both Grades and Pressure are linked independently to Motivation (lines 1-4 in the protocol). Then Grades become identified with Pressure and subordinated to a new notion, Personal Satisfaction. In episode 3 (11.9) Personal Satisfaction is reasserted as a cause of Motivation and the relationship between the two is further defined with the label "major." In episode 4 and 5 (11.15-28) the writer sets up a number of trial relationships in which Grades are still a subordinate element. When, however, we skip to the final draft we find a knowledge map in which Grades and Personal Satisfaction have come to stand as independent parallel causes and each relationship has been further specified by the labels "major" and "initial."

Retrieving knowledge and creating an adequate conceptual

1. L: This is April, 1977, and Wendy is doing a protocol on motivation.
2. W: Ok, um, the issue is motivation and the problem of writing papers. For
3. me, motivation here at Carnegie-Mellon is the academic pressure and grades that
4. are involved, so I'd better put that down. . . . and grades . . . Um, they kind o:
5. compel me, that's really what motivation is, um, kind of to impel or start or
6. a, momentum. (Pause.) Ok, I suppose from the academic pressure of the grades,
7. I'm not sure whether—I think personal satisfaction is important, but I'm not
8. sure whether that stems from academic pressures and grades, or whether—I
9. would say personal satisfaction is a major issue. Ok, um. Oh.

14. Not only do I get
15. satisfaction from my grades, but I also get satisfaction in turning in something
16. that is good quality. So, if I'm happy when I write a good paper, it really doesn't
17. matter what kind of grade I get back on it, if I'm happy with it. So, um, um,
18. let's see. Um, what are the—I'm thinking of, I'm trying to relate personal
19. satisfaction between academic pressure and the grades, but I'm not really sure
20. how to do it, how to branch it.

25. Um but
26. of course, the reason I'm writing the paper in the first place is for that grade,
27. or to relate that back. Those two ideas are very interlocked—maybe that's not
28. the right term. Um, ok.

Figure 2-1: Segments of a protocol

M MOTIVATION
P PRESSURE
G GRADES
PS PERSONAL SATISFACTION
Q QUALITY

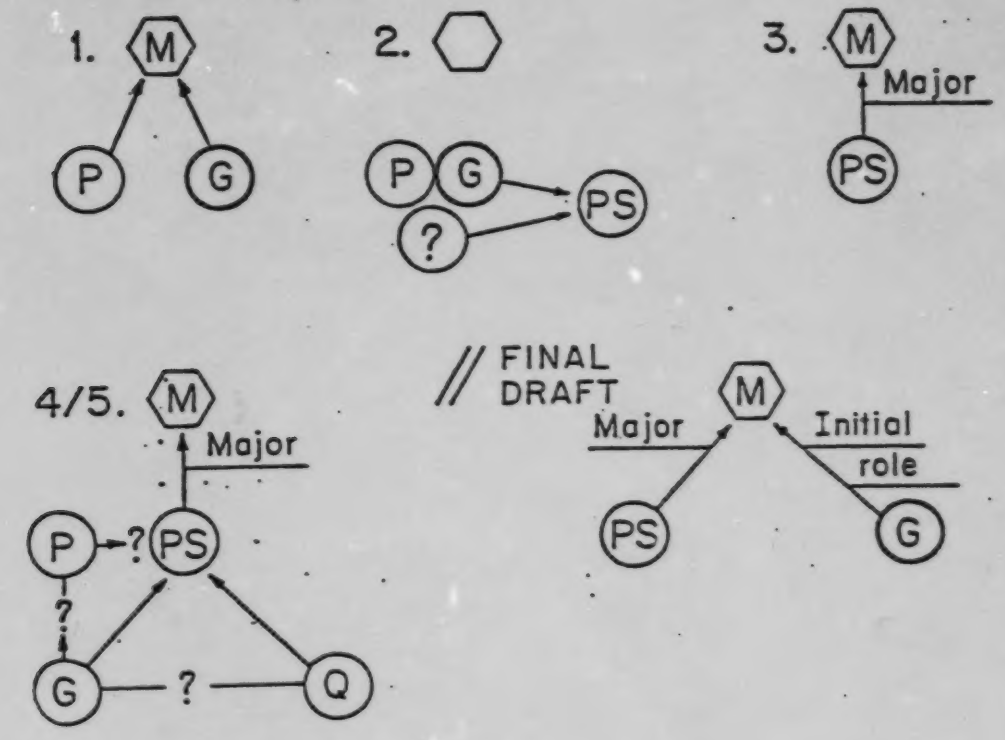

Figure 2-2: The writer's developing knowledge structure

structure of "what you think" can be a demanding task. Sir Phillip Sidney's poetic advice to Astrophel, "Look into thy heart and write," is often a useful heuristic, but it doesn't guarantee you will find a ready-made conceptual structure there.

Written Speech

If we return to the Wendy protocol at line 11, we can see her trying to accommodate a second, even more demanding constraint. In addition to clarifying what she thinks, she is now trying to express that knowledge map within the linguistic and discourse conventions of written prose. Notice too how quickly she has jumped to the added task of producing text: nine lines of analysis and she is ready to set it in type.

There are many ways in which language, which enables us to express complex thought, also constrains our attempt to do it. For the inexperienced or remedial writer the rules of grammar and conventions of usage and syntax may make an enormous demand on time and attention. But even the more experienced writer must encounter the inevitable truculence of language itself which seems to resist our attempts to form a set of continuous sentences with forward and backward reference.

A sentence that is grammatically acceptable may twist the meaning, repeat a word too soon, or have terrible rhythm. In generating a given sentence, the writer needs to meet all of these constraints more or less at once.

The following example illustrates the difference between

1. L: This is April, 1977, and Wendy is doing a protocol on motivation.
2. W: Ok, um, the issue is motivation and the problem of writing papers. For
3. me, motivation here at Carnegie-Mellon is the academic pressure and grades that
4. are involved, so I'd better put that down. . . and grades . . . Um, they kind of
5. compel me, that's really what motivation is, um, kind of to impel or start or
6. a, momentum. (Pause.) Ok, I suppose from the academic pressure of the grades,
7. I'm not sure whether—I think personal satisfaction is important, but I'm not
8. sure whether that stems from academic pressures and grades, or whether—I
9. would say personal satisfaction is a major issue. Ok, um. Oh.
10. L: What are you thinking?
11. W: I'm trying to think of the first sentence to start with. Um, maybe something
12. like, personal satisfaction is the major motivating force in the writing of my
13. papers and reports. Ok, I'm trying to think of—ok, I want to somehow get it into
14. the academic pressures now. Um, well, maybe not so soon. Ok. Not only do I get
15. satisfaction from my grades, but I also get satisfaction in turning in something
16. that is good quality. So, if I'm happy when I write a good paper, it really doesn't
17. matter what kind of grade I get back on it, if I'm happy with it. So, um, um,
18. let's see. Um, what are the—I'm thinking of, I'm trying to relate personal
19. satisfaction between academic pressure and the grades, but I'm not really sure
20. how to do it, how to branch it. I'm really having a hard time getting started.
21. Well, maybe I'll just write a bunch of ideas down, and maybe try to connect them aft
22. I finish. Ok. When I feel that I've written a high quality, and I put in paren-
23. theses, professional, paper, um, to be graded, when I submit it, the grade is not
24. always necessary for the teacher to have the same. Ok, that's kind of _____
25. _____; I'll check with that one. Ok, and—Let's see what else. Um, but
26. of course, the reason I'm writing the paper in the first place is for that grade,
27. or to relate that back. Those two ideas are very interlocked—maybe that's not
28. the right term. Um, ok. I'm not always sure whether my personal satisfaction,
29. this is kind of off on a tangent, and it might not be included in my final draft,

Figure 2-3: Wendy Protocol

knowing something and trying to turn that knowledge into a piece of writing. Wendy has established a knowledge map in which Motivation and Grades are related in three distinct ways. She is now trying to turn that set of thoughts into an acceptable sentence. Where we enter the protocol she is working on the sentences which will become sentences 2, 4, and 6 in the final text.

This excerpt illustrates two interesting points:

1. Complex thoughts don't automatically flower into appropriately parallel complex sentences. Although Moliere's Bourgeois Gentleman was surprised to discover that he had been speaking "prose" all his life, doing so is no mean task. The success that sentence combining exercises claim for improving overall writing skill (O'Hare, 1973) is probably due to their ability to reduce the effect of this linguistic constraint. By making sentence production processes somewhat more automatic, the writer has time to concentrate on other important constraints.

2. In addition to producing a verbal rendition of thought, our writer must also work within the conventions of written speech, particularly those conventions which distinguish oral speech from writing and make writing a specialized form of discourse. Even from this brief protocol passage we can infer that the writer probably has a set of rules or adages about paper writing which say:

- Be specific.
- Repeat ideas for emphasis.

Sentences from final version:

- # 2. Because of the emphasis on 4.0s here at CMU, grades become an instinctive motivator for myself.
- # 4. The initial motivator in the outset of writing a paper is the fact that a grade will be attached to it upon completion.
- # 6. After I begin writing a paper, the grade emphasis diminishes and a higher level of personal satisfaction takes over.

Protocol excerpt:

Um, because of the, maybe because of the emphasis--Um, four-o's. Trying to be more specific. Um, even though I don't have a 4.0. Um, because of the emphasis on 4.0's. Ok, because of the emphasis on 4.0's grades are maybe a a natural, or maybe instinctive, are instinctive motivator.

So um, ok. The initial motivator, this is, grades are natural instinctive motivator,--I should say initially again, but I'm not really sure how to say it. Ok, well maybe I can leave it natural, or instinctive--maybe that'll bring that out. Um, ok, maybe I can refer toward initially again. After the um, after I begin perhaps, writing. Ah, a paper, the fact that a grade, wait a minute, the fact that a grade, I don't know if I used later, attached--eh, I did, I don't want to use that again. Ok, um.

After I begin writing a paper, the grade emphasis--I don't know if I want to use that again--the grade emphasis is foreshadowed by the, by the fact or maybe I'll come back and put that in...oh, ok. After I begin writing a paper the grade emphasis is foreshadowed by the something, um, something that instead,--I'll have to look up the wording.

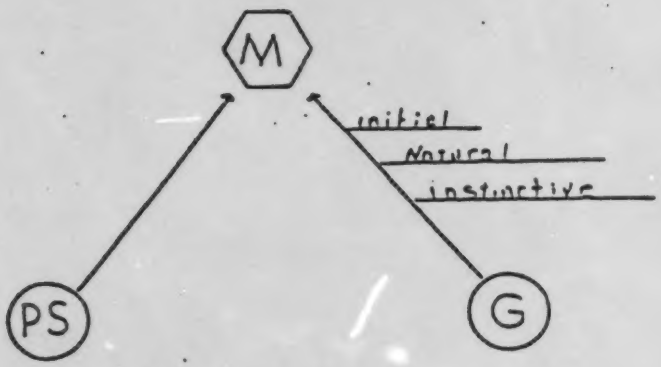

Figure 2-4: Turning thoughts into acceptable sentences

- Refer back for coherence.
- Don't repeat words/phrases in close priximity.
- Use "correct" (?) wording.

Turning verbal thought into text is a demanding task. Mina Shaughnessy's work with Basic Writers (1977) has shown that many of their writing errors come from a misapplication of oral speech conventions to writing. Other writers have suggested that although written speech is a specialized and difficult convention to master, it is the language of modern education. In particular, David Olson and E. D. Hirsch have recently described the difference between an utterance and a text in terms of our expectations that a text will be fully contextualized (Olson, 1977; Hirsch, 1977). In other words, we expect that the meaning in written speech will be fully contained and explicitly present in the text itself--as it never is in oral speech. By contrast, the meaning of an utterance often depends in large part on a context shared by speaker and listener, on the immediate situation, shared intentions, prior knowledge, and, of course, on many forms of paralanguage--tone, emphasis, and body language. To compensate for all that lost contextual meaning, the writer of a text must draw on the specialized conventions of written discourse in order to contextualize her meaning. A writer is not simply expressing herself; she is creating a peculiar kind of artifact.

Hirsch sums up this position in describing two sets of such conventions:

1. The scribal, lexical, and syntactic conventions of the

normative written dialect: what we generally call the "basic" skills;

2. The stylistic conventions which make it possible to communicate with a large, distant, and diverse readership by providing expectations, frequent closure, and an adequate context for statements.

Olson and Hirsch have described some of the constraints imposed by written speech by a study of the text itself. However, this constraint of "text-making" also affects the writer's process. One of the important things protocol analysis reveals is that a great part of skill in writing is the ability to monitor and direct one's own composing process. This, we think, will be a valuable and fascinating area for research, but one which we can only touch on here. As you could see in the protocol (Figure 2-3), Wendy had to decide how to get started, what to do next, and how to keep track of where she had been and where she wanted to go. Handling the very process of composing itself is a demanding and, no doubt, learned procedure. Some writers have a large and powerful repertory of composing skills; others don't. For example, not all of our subjects are able to tell themselves to jot down ideas and connect them later when it would be quite useful to do so. They seem to lack this degree of conscious control over the process of writing itself.

To sum up then, the linguistic conventions of written speech constrain writers in two important ways. Not only must they learn many conventions peculiar to written speech, they must learn how to handle the rather long and complicated process of composing itself. Our subjects have already shown us that there are significant differences between writers in their organization

and control of the composing process.

Rhetorical Problem

Finally, the task of writing is complicated by one last and very large constraint: the demands of the rhetorical problem. Whatever a writer chooses to say must ultimately conform to the structures posed by her purpose in writing, her sense of the audience, and her projected self or imagined role. In essence, writing is also a speech act and therefore subject to all the constraints of any interpersonal performance.

In practice this means that the writer must adapt both knowledge and written speech to solving this rhetorical problem. For some writers this is the straw that breaks the camel's back. Although the Rhetorical Problem is an added constraint, it can't conveniently be "added" at the end since in theory it should direct the entire process of generating knowledge and language.

Juggling Contraints

Having described some of the constraints of writing, let us look at how people deal with them. It is no wonder many find writing difficult. It is the very nature of the beast to impose a large set of converging but potentially contradictory constraints on the writer. Furthermore, to be efficient the writer should attend to all of these constraints at once; when all is said and done they must be integrated. One doesn't, for example, generate all of one's knowledge on a topic and then decide what to do with it. Ideally, each utterance a writer

generates would be at once perfectly accurate, well-formed itself, integrated in the text, and rhetorically effective. Unfortunately, this ideal rarely occurs because of the limited number of items our short-term memory or conscious attention can handle. Humans are basically serial processors and not well adapted to handling a large number of simultaneous demands on attention (Newell and Simon, 1972). This means that we must handle converging constraints by juggling them in clever ways. The remainder of this paper will look at some of the important strategies writers use to deal with the problem.

The use of strategy in writing is analogous to the use of strategy in concept attainment. In A Study of Thinking, Bruner, Goodnow, and Austin described strategy as a "pattern of decisions" taken to meet certain objectives (1956, p. 54). In both cases the writer/thinker is trying to reduce what Bruner et al. called "cognitive strain," that is, the demand placed on short-term memory or conscious attention. In various ways each strategy we describe will either decrease the number of constraints being acted on or it will lower the level at which they are deemed satisfied. The catch is that some strategies which are very effective at reducing "cognitive strain" are not particularly effective at producing good writing.

Strategies for Reducing Constraints

In theory the most obvious solution to the problem of excessive constraints is to divide writing up into temporarily independent stages such as Pre-Write, Write, and Re-Write or

Gather Information, Outline, Write, and Edit. But in practice this solution often violates the very nature of writing which demands integration of all these elements. Perhaps that is why the writers we have studied don't work in this way, but appear to depend on other strategies to reduce constraints.

1. Throw a constraint away. When a juggler has too many balls to keep in the air, the easiest solution is to simply toss one out over her shoulder. Writers can do this, too, for example by simply choosing to ignore their audience or the convention which demands coherence between paragraphs.

2. Partition the problem. One powerful problem-solving strategy is to break a large complex problem down into semi-independent subproblems. Writers do this in a general way when they plan to write and revise. However, within the act of composing itself writers often depend on a shifting, selective focus of attention. Like the shifting focus of a moving spotlight, a writer might alternate between simply generating ideas and then testing them against an imagined reader.

In teaching composition, the argument for heuristics (Flower and Hayes, 1977) and especially for invention procedures (Young, 1970) rests on the notion that by partitioning a problem you reduce the number of constraints active at one time and secondly, that by concentrating on a subtask you do the task more effectively. However, a word of caution is in order. The kind of partitioning we are describing here should not be confused with the notion of stages in the composing process. Mental

operations such as Generating or Editing can be done independently, but within the act of composing they occur in interactive, recursive patterns, not stages.

Although partitioning is a powerful strategy, it raises a question: how do the pieces get reintegrated? Obviously, a strategy such as write and revise, which simply ignores some constraints until later, will work better for lower level concerns such as correct spelling. But partitioning alone will not be enough to deal with such integral constraints as achieving a rhetorical purpose.

3. Set priorities and "satisfice." Writing is a complex task. The Platonic entity "good writing" has so many possible features, from truth telling to tone control, that a writer must generally choose which goals to achieve at what level of success. Writers inevitably set such priorities in the way they define their Rhetorical Problem (e.g., this is a letter to Aunt Tilly so you can safely ignore run-on sentences and fragments; she won't mind). In setting certain priorities (e.g., be friendly and write at least two pages), writers in effect eliminate some other constraints or reduce the level at which they will be deemed satisfied.

Although setting priorities works to diminish the problem and reduce cognitive strain, it would be foolish to treat the strategy itself as a rational or even purely "cognitive" decision. As Britton has described, many affective concerns shape the writer's priorities and her definition of the task

(e.g., see if you can write three pages that won't get any red marks this time) (Britton, 1975). A writer's motivation and self-confidence can dictate a definition of acceptability which might be only loosely tied to her actual ability.

In school, "bad writing" is often the name we apply to writing whose priorities we feel to be askew. For example, the "theme writing" criticized by Coles and others (Coles, 1974) is a student genre characterized by a facile use of inflated language and a concern for correctness at the expense of honesty, emotion, and imagination.

As a corollary to giving some constraints a high priority, writers then choose to "satisfice" on others (Newell and Simon, 1972). A writer "satisfices" by choosing to take the first acceptable solution. For instance, instead of struggling to find the "best" way to say something, she satisfices with the first "acceptable" sentence and moves on to other matters. Writers often combine this strategy with partitioning, when they decide to satisfice on certain things in a first draft and improve them in revision. A side effect of satisficing, which we see in techniques like brainstorming, is that in reducing the cognitive task, it also reduces a writer's performance anxiety. This in turn frees more of the writer's attention for the real problems.

4. Draw on a routine or well-learned procedure. One way to reduce cognitive strain is to depend on procedures which are so automatized or routine that they don't require conscious processing in short-term memory. For example, experienced

writers usually devote very little conscious attention to tasks such as typing, producing grammatical sentences, or even meeting the demands of a particular genre, whereas these tasks can overwhelm inexperienced writers. Even some very high level tasks can be treated as routine if the writer has a stored frame or schema in memory to draw on. For example, the conventional frame for the outraged, solid citizen's letter to the editor could make such a letter relatively easy for most of us to write. It specifies not only the writer's role, his tone of voice, and a set of stock phrases ("This injustice should not be allowed to continue!"); it also supplies at least a skeletal rhetorical structure and a declamatory sentence style.

Drawing on routine procedures or stored frames is a powerful strategy because of its great cognitive economy. Learning how to write itself is in part the process of making certain subtasks so automatic that we open up processing space in short-term memory and increase our capacity to deal with those harder tasks which require conscious attention (Nold, in press). The limitation of the strategy is of course its inflexibility. A stereotypic plan is only effective when it meets the appropriate stereotypic situation.

5. Plan. If excessive constraints have been the villain of this piece, Plans are most likely to be its hero because planning can not only reduce constraints but integrate them. As an important strategy in all kinds of problem-solving activity, Plans tend to work in three ways: by modeling, abstraction, and analogy (Hayes, 1978). An outline, for example, is essentially a

miniature model of the proposed solution. A model, of course, is much cheaper to build than the full-sized solution would be, if, for example, the goal were a battle ship or a 20-page paper. The model lets the writer 1) define manageable subproblems and 2) test and discard alternatives. However, if the model is not cheap to build--if it is a 5 page typed outline--the writer may be very reluctant to discard her plan whether it's good or not. In the early stages of writing it is important to use plans which are detailed enough to test, but cheap enough to throw away.

Planning also works by abstracting the essential features from something complex (Miller, 1960). Plans reduce a large unwieldy problem loaded with constraints--such as, write a perfect paper-- down to a simpler one--jot down your main ideas. Such plans are like a designer's sketch: they focus on the essentials; they set priorities. By setting priorities plans also tell you how to go about solving the problem. For example, the designer's plan or sketch for a new garden will probably include only the major elements, the plots, the paths, the existing trees, but will probably exclude individual dandelions and transient insects. Just so, a writer's plan isolates key issues and goals out of that tide of details and language which often sweep writers away before them. Plans are, in a sense, the writer's defense against the very nature of writing and its deluge of constraints. They offer a touchstone or a steady reference point in one's effort to create sentences and a text. By contrast some writers often try to figure out their ideas and goals by trying to write a perfect introductory paragraph.

Plans can of course be elaborate, detailed, and formal, but the most useful plans we have seen appear to be the sketchy flexible sort which recognize priorities and define the writer's high level goals. As the writer works, a sketchy plan (such as, try to present ballet to teenage boys as a form of athletic skill) becomes fleshed out in close interaction with the act of generating and organizing ideas. Good plans appear to be like an artist's sketch in which the essentials are suggested but implicit in the movement of a line. Again, good plans are rich enough to work from and argue about, but cheap enough to throw away.

Planning has another virtue; it is a higly teachable strategy. In trying to bridge theory and practice we are going to describe three kinds of plans writers make and teachers might teach. In making this jump from analysis to teaching it might be useful to review where we have been. Our argument so far has been basically this: contrary to some traditional notions, the writing process is not a neat, additive sequence of stages. Instead the task of the writer is better described as an attempt to juggle three sets of constraints, all of which should impinge on the final product. The writer's problem then is how to keep all of these balls in the air given the limits of our short-term memory--our capacity to juggle.

One of the most effective strategies for reducing cognitive strain without ignoring interacting constraints is planning. Therefore it is no surprise that in the writers we have studied, planning takes up a good deal of the time spent composing.

Furthermore, good writers appear to have more flexible, high-level plans and more self-conscious control of their planning than poor writers (Flower and Hayes, in press). It is our thesis that one way to improve people's writing is to improve the planning process they go through as they write.

A Taxonomy of Writing Plans

We know that writers generate an enormous number and variety of plans as they compose; the problem is how to categorize these plans in a useful way. Our hypothesis is that writers draw on three major kinds of plans which are hierarchically related to one another.

Plans to do. To begin with, writers generate plans for dealing with their Rhetorical Problem. We call these rhetorical plans, plans To Do something in or by language. These are essentially plans for performing a speech act, for responding in some way to that rhetorical problem which includes the writer, the reader, and a purpose. A plan To Do something in writing might be as unique and specific as "Write a note for the icebox door to keep the family out of the plums. Use a stern parental voice that begins with firm reasonableness and ends with a veiled threat." At the other extreme a rhetorical plan could be as conventional and limited as "write another essay for Freshman Composition class." As you might expect when writers fail to plan or depend on limited, stereotypic plans, they are likely to spend very little time actively considering audience or purpose when they write. They are more likely to produce "Writer-Based prose"

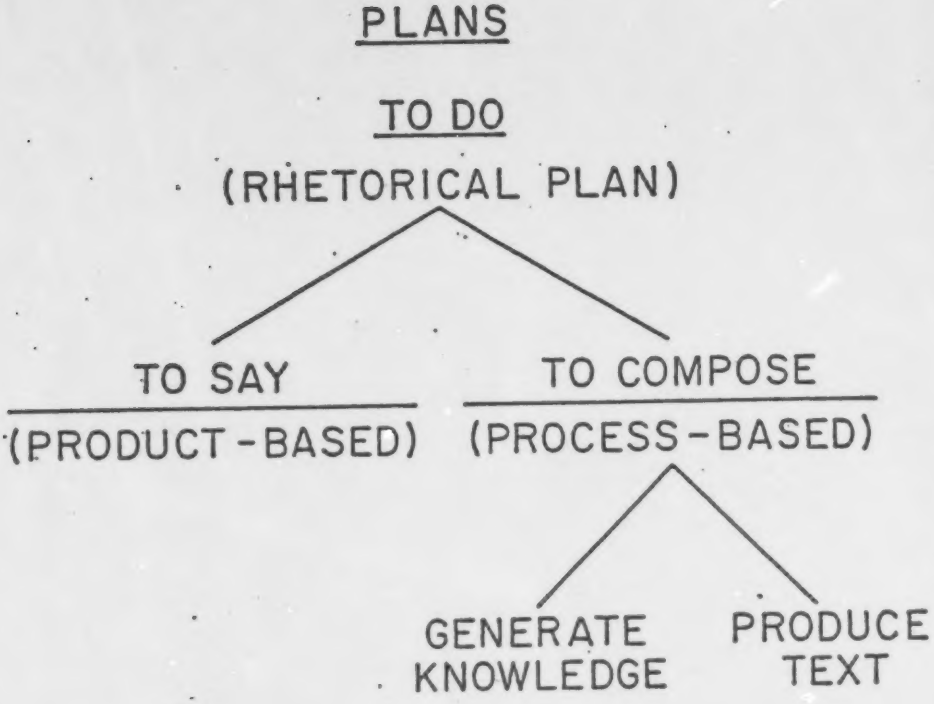

Figure 2-5: Plan for dealing with a Rhetorical Problem

which takes on the structure of the writer's own thought process and the style of an interior monologue (Flower, in ms.).

A rhetorical plan To Do something can not only improve the quality of a paper; it can also make it easier to write. When people treat writing as a speech act they are more likely to draw on many of the well-learned strategies adults use every day for arguing, explaining, or describing, but which many seem to ignore when they are writing for a class. A rhetorical plan offers the writer a pole star for the choppy sea of trying to compose.

How can we help students to make vigorous plans To Do something? A recent stuy by Scardamalia, Bracewell, and Bereiter (1978) suggests that assignments which specify the audience in some detail act as important cues to the writer. They help him "decenter" from his content or information and adapt his knowledge to a reader.

If you want to get better writing from your students, one of the most effective ways to do it is to create assignments which have a realistic purpose and a real audience (not a teacher) who actually needs to know something. For example, one can request a written plan from students two weeks in advance in which they identify the reader and his needs, their role vis-a-vis that reader, and the impact they expect their paper to have. Many times this plan can become the problem-purpose statement that introduces the paper.

Plans to say. In order to carry out a plan To Do something, writers often generate two kinds of subplans. The first of these

is the familiar and rudimentary plan which every school child has had drilled into him in the form of outlining: a plan for what you want To Say. A plan To Say something is essentially a content plan--a simplified or abstract version of the information you want to convey. It can take a variety of forms ranging from scribbled notes and sketches on an envelope to an impressive sentence outline complete with Roman numerals and two subpoints under every point. A plan To Say is essentially a scale model of the final product. Perhaps that is why it has been so widely and rigorously taught, often to the exclusion of any other kind of planning.

Composing plans. There is, however, another kind of planning writers do which is based not on the product of writing, but the process. This third kind of plan we call a Composing Plan.

Some Composing Plans help people generate knowledge. In classical rhetoric such formalized plans go under the name of invention. One can choose from highly systematic and analytical plans such as the particle, wave, field analysis of tagmemics, to Aristotle's topics or Gordon's synectics, or from more enigmatic and inspirational plans such as Sheridan Baker's advice on "picking an argument" or the meditation techniques used in Pre-Writing, on down to the time-honored methods of poetic inspiration, "Look into your heart and write." If you wish your students to have more self-conscious control over the process of generating ideas, there are many ways to teach it.

The category of Composing Plans also includes a large set of

ad hoc plans people use to guide themselves through the process of writing. For example, when the writer in the Wendy protocol ran into trouble, she told herself to "write a bunch of ideas down and connect them later." Some of our subjects appear to be at the mercy of inspiration as they compose or slaves to their own growing text. Others are able not only to monitor their composing process, but to choose alternative ways to proceed. At the base of our work with heuristic strategies for writers (Flower and Hayes, 1977) is an attempt to learn more about these unexplored alternative strategies within the art of composing itself.

Let us close with an excerpt from a protocol which illustrates a writer working under a top-level plan To Do something, which in turn creates a nested set of goals and subgoals. As the protocol develops we will see how the writer's forward progress is the result of a recursive, non-linear process guided by a variety of plans. As an illuminating contrast to this subject, we studied another writer whom we shall call "Freewrite." As he composed, Freewrite's top-level plan appeared to be "Write whatever comes to mind." His guiding plan was essentially a plan To Say, with only a rudimentary set of composing rules tacked on (e.g., use correct grammar, use correct spelling if you know it, and paragraph occasionally). His protocol showed almost no discernable attention given to audience or purpose, and the final product, as you might guess, read rather like a transcript of free association, even though the writer considered it quite adequate.

Let us return then to the writer working under a top-level plan To Do. This schmatic version of a protocol covers the beginning of the composing session. The plans To Do and To Compose are generally comments the writer makes to himself whereas the plans To Say are frequently notes jotted on paper. Notice how the first three moves essentially define the rhetorical problem.

- By move 4 the writer has sketched out the rhetorical problem (his purpose, audience, and his own role) and set up a composing plan (just jot things down). When he begins to explore his knowledge at move 4, it is under the simultaneous control of these two plans.

- Move 5, a decision to keep on generating ideas, is a reaffirmation and development of the initial composing plan in Move 2.

- By move 7 the information the writer has generated leads him to form a new plan which is both a Composing plan for the final paper and a plan To Do something--to make a point for the reader.

- Move 9 is probably the most illuminating point of the protocol because the writer encounters a mismatch between his Knowledge (things he could say about Memory I) and his goal <u>vis-a-vis</u> the reader. His action demonstrates the distinction between Knowledge and Goals in writing. His high-level plan To Do, based on his purpose and reader, lets him consider two subplans (make the subject itself important or focus on its underlying principle) and in turn two pockets of knowledge. In the process of working by plan our writer considers two radically different things he could say. Clearly his writing process is not simply the straightforward act of expressing what he knows. Instead it is a hierarchically organized, recursive process in which knowledge and text are generated under the direction of both a rhetorical plan To Do something and a Composing plan for how to do it in writing.

This fragment of protocol was the beginning of the subject's writing session. At the end of the session, forty minutes later, there was an unexpected coda: the writer discovered that his initial objective of "justifying Memory I" has been entirely

PLANS:	TO DO	TO COMPOSE	TO SAY
1)	Write an exposition for humanities teachers about Memory I (a group of specialized memory techniques).		
2)		What I'll do is jot down random thoughts about	
3)	What the teachers might want to hear and I might want to tell them.		
4)			First thing occurs randomly is encoding.
5)		That word means a lot but I won't explain it now.	
6)			Thinking about objections heard at the workshop. Note memory is trivial.
7)		A point I will want to make someplace is that	
8)			Memory I procedures are useful in modern language. They are also more useful generally. Unfortunately, by more generally I mean things like grocery lists.
9)	One of the problems in writing this essay will be to expand on that usefulness and make it seem more plausible. To make uses more general and acceptable. That's the wrong word; I mean important seeming. Uh. Or, if that's not the solution to the problem, alternate approach is to say		
10)			so those applications aren't important. What is importa is the instructional value
11)		Not the right word but what the hell	
12)			of the demonstration of encoding

Figure 2-6: Excerpt from a protocol: Working by plan

forgotten in the course of composing a different line of argument. He now sees that Memory I (and the ideas generated in our excerpt) could be an example in this larger argument. In the brief section below he sets up a new plan (which is both a rhetorical and a composing plan) and begins to compose text.

This excerpt illustrates what is probably one of the critical differences we have seen between the processes of good and weak writers. A weak writer in this situation would probably continue to crunch out text under the direction of a plan To Say what he know or a plan To Compose his information into "acceptable" text. A good writer, by contrast, not only makes initial high-level plans To Do something, but continues to return to and develop those plans as he writes.

In applying this discussion of planning to teaching, one thing stands out. Outlining--that old warhorse of composition teaching--can fail to help students if it only encourages them to plan what they want To Say, that is, to record and organize information. Outlining and in fact any technique for organizing ideas can be a powerful tool. But perhaps we have concentrated too long on teaching plans To Say at the expense of the other kinds of plans writers also need to make. As we all know, in effective writing a meaningful organization of information takes its logic from the writer's higher-level plan To Do something. Perhaps we need to teach such plans more vigorously. Secondly, even if a writer knows what she wants to accomplish and what to say, she must still face the task of trying to compose. Good writers have plans and strategies for handling this task. One of

Lines in italics are fragments of the growing text interrupted by plans and meta comments.

PLANS:	TO DO	TO COMPOSE	TO SAY
1)	If we were to describe Memory I (as an example) what do we want to say about? (Searches notes) There it is. Let's do that.		
2)		All right, I will take/take as an example of the sorts of material . . . presented in the course . . . Now this is a terrible sentence but we can revise it. . . . the first subunit of . . . unit . . . unit That's not quite right, but, called Memory I. In Memory I, Memory I . . . In Memory I the students learn . . . Now what am I going to do here cause I don't really have an organization for Memory I yet. . . . the students learn . . . Now at this point we should break off and plan.	
3)	Let's see . . . now what we want to get across in this plan, we want to illustrate the practical nature . . . nature of skills . . .		

Figure 2-7: Protocol of the beginning of a writing session

the current tasks of rhetoric will be to explore and explain those skills which govern how we write.

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3. Writing as Problem Solving

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It's very exciting to be doing research on compostion just now because a great deal is happening. Theorists are exploring new ideas and experimenters are providing us with new empirical results at an unprecedented rate. Currently there are at least four major theoretical viewpoints guiding the work of researchers who are trying to understand composition:

1. The psycholinguistic viewpoint, represented by Kintsch, Van Dijk, Rumelhart, and others;
2. The linguistic viewpoint, represented by Young, Odell, Cooper, de Beaugrande, and others;
3. The developmental viewpoint, represented by Bereiter, Scardamalia, Bracewell, and others; and
4. The cognitive processing viewpoint, represented by Collins, Nold, Flower, and Hayes.

A casual observer could easily find this multiplicity of approaches confusing. Even researchers active in the field may sometimes find it difficult to characterize their own research. Their attention is likely to be directed at the subject matter they are trying to understand rather than at the assumptions underlying their research methods. In this paper we will stand back from the research we have been doing for the last several years and attempt to say what it is we think we have been doing.

There are two major factors which have shaped our work on writing. First, in conducting our research we have made a number of strategic decisions about what is interesting and about how

best to proceed. To put it plainly, these decisions are the incarnation of our scientific biases. Second, our research has been shaped by a refractory world which has insisted that we attend to certain salient facts about the writing processes. In what follows I will describe the strategies which we have chosen to guide our research and then the facts which nature has imposed on us.

Strategic Decisions

Our approach proceeds from five strategic decisions which we made about how to conduct our research. Briefly these decisions were:

1. to focus on the act of writing;
2. to try for a process model of writing;
3. to model individual writers;
4. to work wholistically or "top down"; and
5. to divide the writing task into parts for easier analysis.

As we will see below, these decisions are genuine ones in the sense that we could reasonably have made other choices. Alternative approaches to the study of writing do proceed from different decisions on these same issues.

1. Our first and most important decision was to focus on the act of writing--that is, to attend to whatever it is that writers do when they produce a text. Thus, we viewed writing primarily as a process rather than as a product. We felt that by far the richest source of information about writing would be to

observe step by step how the writer had actually created the essay. However, we did not intend to ignore the product. Wherever possible, we looked to the writer's essay for evidence to confirm or elaborate the more direct observations of process.

To observe writers in action we have employed process tracing methods borrowed from cognitive psychology. In our studies, a typical experiment proceeds as follows: subjects appear at the experimental session knowing that they will be assigned a topic on which to write an essay and that the whole procedure will take about an hour. Further, they know that they will be asked to "think aloud" while writing. The subject is seated in a quiet office with a desk, pencil, and paper, and the tape recorder is turned on. The experimenter then gives the subject an envelope containing the writing assignment--that is, the topic and the intended audience. The subject then busily sets to work writing and commenting roughly as follows: "Well, open up the magic envelope. OK. Whew! This is a killer. Write about abortion pro and con for Catholic Weekly. OK, boy! How am I going to handle this?", etc. This continues for about an hour until the subject says something like, "Well, that's it. Good-bye, tape recorder [click]." The data of the study consist of a verbatim transcript of the tape recording (with all the "um's" and pauses and expletives undeleted) together with the essay and all of the notes the writer has generated along the way. The transcript is called a protocol. These materials are then examined in considerable detail for evidence which may reveal something of the processes by which the writer has created

the essay. In general, the data are very rich in such evidence. Subjects typically give many hints about their plans and goals, e.g., "I'll just jot down ideas as they come to me"; about strategies for dealing with the audience, e.g., "I'll write this as if I were one of them"; about criteria for editing and evaluation, e.g., "For 10-year-olds, we better keep this simple"; and so on. The analysis of this data is called protocol analysis.

2. To understand the writing act, we certainly need to identify the processes involved--but this is not enough. We also need to know how these processes are organized to produce a text. That is, we need to know how the processes are sequenced, how one process is terminated and how the one which follows is chosen, how errors are detected, etc. Further, we want to know how simultaneous processes interact. When writers construct sentences, we want to know how they handle such multiple constraints as the requirement for correct grammar, appropriate tone, accuracy of meaning, and smooth transition. In short, we want a model which specifies the processes involved in writing and accurately describes their organization and interaction.

A model is a metaphor for a process: it's a way to describe something, such as the composing process, which refuses to sit still for a portrait. People build models in order to understand how a dynamic system works, and to describe the functional relationships among its parts. In addition, if a model is to really help us understand more, it should speak to some of the critical questions in the field of writing and rhetoric. It

should help us see things in a way we didn't see them before.

Our second strategic decision was to direct our research toward the construction of such a model. Ideally, the model should be capable of telling us how writers go about producing a text when they are given a writing assignment. It should tell us what processes are involved, in what order they occur, and at what points the writer will experience difficulty. At present, of course, we must be satisfied with a model which is much less complete than the ideal. The ideal defines where we would like to go, but, alas!, not where we are now.

3. It is apparent that not all writers write in the same way. For example, some writers plan their essays from beginning to end before they write a single word of text, while others never seem to look beyond the next sentence. Further, some writers seem to write with their readers constantly in mind, checking frequently to be sure that they have taken the reader's knowledge and attitudes into account. Other appear serenely unaware that an audience could fail to understand what they, in good faith, have intended to say.

In modeling, we can deal with such differences in either of two ways. We can choose to construct a model of the "average" writer and delay until some more propitious time the description of differences among writers. This approach has the merit of simplicity. Further, if things work out well, a model of an average writer might be useful in characterizing individual differences. Thus, models for individual writers might prove to

be minor variants of the average model. However, this approach may have the disadvantage that averages sometimes suffer from--the average may be representative of no one. Thus, we sincerely hope that no one has the average number of children--two and a half--nor would we want anyone to have to eat an average course at dinner, which might be a compromise between appetizer and dessert such as oysters with chocolate sauce.

An alternative approach is to construct models which are intended to describe individuals rather than averages of groups. The disadvantage of this approach is that it may be expensive. In the worst case, each individual may require a separate model. With better luck, models of individual writers will turn out to be variants of a small number of model types. The advantage of this approach is that it is more likely than a model of the average to capture the behavior of actual (rather than idealized) writers.

Our third strategic decision, then, was to model the behavior of individual writers rather than the average behavior of groups of writers.

4. In studying writing, we might well have started with processes which psychologists and psycholinguists have already identified as fundamental ones--processes such as short-term memory, grammatical categorization, and lexical marking. We might then have attempted to synthesize more complex processes using these fundamental processes as building blocks. This synthetic or bottom up approach is a very familiar one in science

and has frequently been used with great success. Geometry and Newtonian physics are perhaps the best known examples.

However, research often proceeds in the opposite direction, that is, wholistically, or from the top down. Chemistry provides a good example of top down research. Chemical research often starts with a complex compound and then looks for the elementary components and their relations. The top down approach is the one we have chosen to apply in our writing research. We have started from the top with the complete writing act and have attempted to analyze it first into a few relatively complex subprocesses. As the analysis proceeds, the complex subprocesses are analyzed further into progressively simpler subprocesses. Ultimately, we hope that this top down analysis will make contact with the fundamental processes which psychologists and psycholinguists have already identified. Thus, the top down and bottom up approaches may be viewed as complementary.

The advantage of the bottom up approach is that it is rooted in fundamental processes. The advantage of the top down approach is that its results are almost certain to be relevant to real writing situations.

5. Our final strategic decision was to divide the writing task into three parts:

A. The writer's long-term memory;

B. The writing processes--that is, the writer excluding the writer's long-term memory; and

C. The task environment--that is, the world outside the writer's skin. The relevant parts of the task environment are assumed to be:

- The rhetorical situation--that is, the specifications of topic and audience to which a writer must respond; and

- The text which the writer has produced so far. This text becomes an increasingly important part of the task environment as writing proceeds.

We chose this division because it is an especially convenient one for psychological analysis and modeling. Transfers of information between the task environment and the writer are usually marked clearly by overt acts of reading or writing. Further, information retrieval from long-term memory is frequently detectable by examining the verbal protocol. Thus, the boundaries we have chosen divide the writing task into parts whose interactions are relatively easy to observe.

Bitzer's analysis of the rhetorical situation (1968) focuses on the importance of the task environment. Lowes' classic study of Coleridge (1927) focuses on the importance of the writer's long-term memory. Our own research has focused on the writing processes.

Our Model

While we don't want to present our model in great detail (that has been done elsewhere; see Hayes and Flower, 1979), we do want to show enough to illustrate how it had been shaped both by fact and by our strategic decisions.

Figure 3-1 shows the overall structure of the model. That we have a model of the writing act at all, of course, illustrates our first two strategic decisions: to focus on the writing act

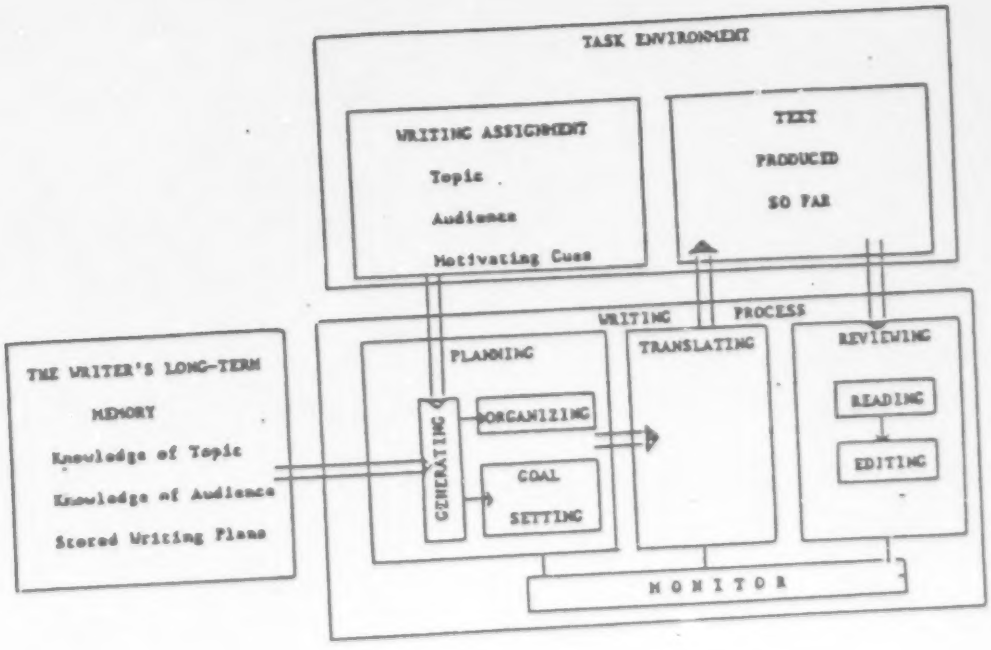

Figure 3-1: Structure of the writing model

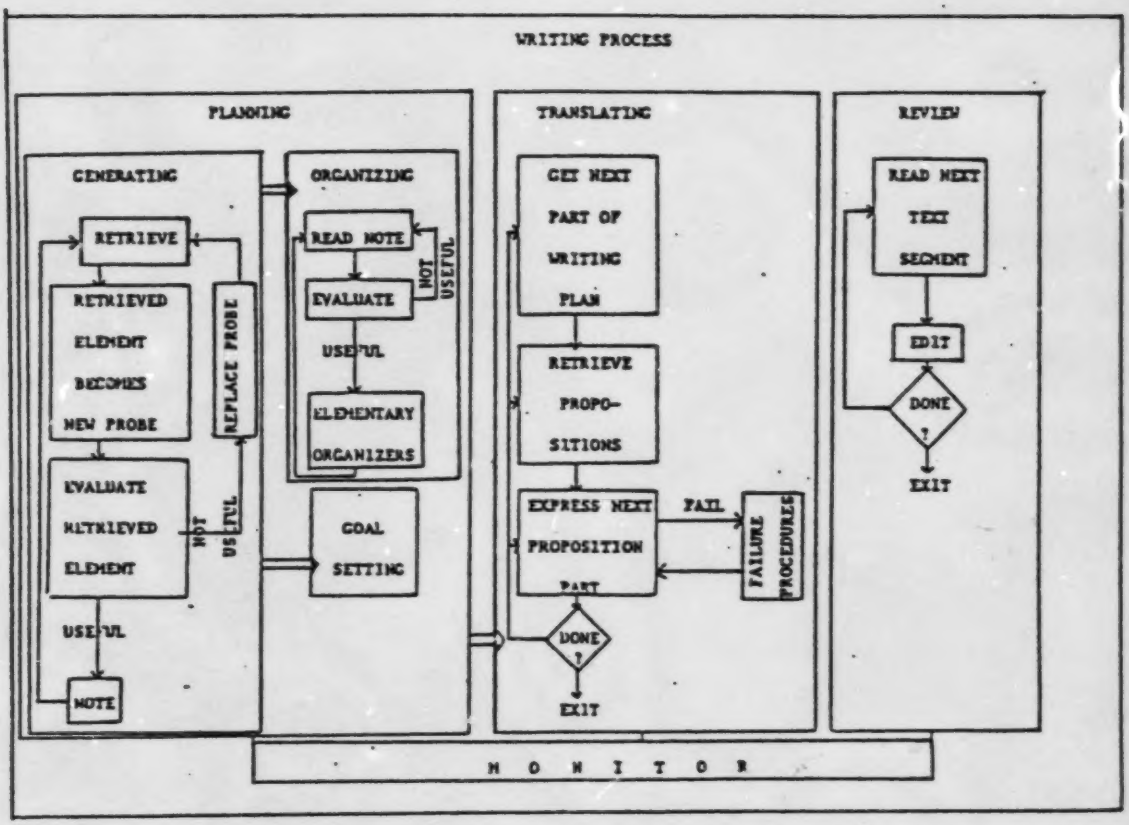

Figure 3-2: The writing process

and to model it.

The effect of our fifth decision--to divide the writing task into task environment, long-term memory, and writing process--is also evident in Figure 3-1.

1. (Generated language in STM ——> edit)
2. (New information in STM ——> generate)
3. - 6. Goal setting productions (These vary from writer to writer; see Fig. Y.)
7. [(goal = generate) ——> generate]
8. [(goal = organize) ——> organize]
9. [(goal = translate)——> translate]
10. [(goal = review) ——> review]

Figure 3-3: Monitor

Figure 3-2 shows the subprocesses of the writing process. Figure 3-3 shows the inner structure of one of the subprocesses--the monitor. The progression from Figure 3-1 to Figure 3-3 parallels the progression of our top down approach. At first we analyze the writing act only into its largest, most evident components. Then, as research proceeds and as data allow, we analyze these major components successively into more

refined subparts.

The function of the monitor (see Figure 3-3) is to control the sequence of writing processes. For example, it determines when idea generation will stop and organizing processes will begin. The middle section of the monitor--rules 3 through 6--is variable in form to allow for differences among writers in the way writing processes are sequenced. Figure 3-4 shows four alternative forms for rules 3 through 6. The first form represents a writer who polishes each sentence before considering the next. The fourth form represents a writer who plans the entire essay before writing the first sentence.

We know, of course, that there are many more differences among writers than the few we have discussed. Our strategic decision to model individual writers will lead us to search for other variations in the model which will allow us to describe other individual differences. We expect, for example, that some novice writers may entirely omit one or more of the major processes employed by competent writers. We have frequently observed writers who omit the review process--this is perhaps the commonest problem found in papers handed in at the last minute--and we have found at least one writer who showed no trace of an organizing process.

The Facts

Over several years, as we applied our research method to the analysis of writers in action, we were forced to a number of conclusions about the writing process. Among these conclusions,

Configuration 1 (Depth first)

3. [New element from translate ⟶ (goal = review)]
4. [New element from organize ⟶ (goal = translate)]
5. [New element from generate ⟶ (goal = organize)]
6. [Not enough material ⟶ (goal = generate)]

Configuration 2 (Get it down as you think of it, then review)

3. [New element from generate ⟶ (goal = organize)]
4. [New element from organize ⟶ (goal = translate)]
5. [Not enough material ⟶ (goal = generate)]
6. [Enough material ⟶ (goal = review)]

Configuration 3 (Perfect first draft)

3. [Not enough material ⟶ (goal = generate)]
4. [Enough material, plan not complete ⟶ (goal = organize)]
5. [New element from translate ⟶ (goal = review)]
6. [Plan complete ⟶ (goal = translate)]

Configuration 4 (Breadth first)

3. [Not enough material ⟶ (goal = generate)]
4. [Enough material, plan not complete ⟶ (goal = organize)]
5. [Plan complete ⟶ (goal = translate)]
6. [Translation complete ⟶ (goal = review)]

Figure 3-4: Alternate configuration for the monitor

the most important in shaping our model of the writing process are these:

1. Writing is goal directed.
2. Writing processes are hierarchically organized.
3. Some writing processes may interrupt other processes over which they have priority.
4. Writing processes may be organized recursively.
5. Writing goals may be modified as writing proceeds.

1. Writing is goal directed. Evidence that writing is goal directed is easy to find in the protocols. Typically, writers comment on their major goals early in the writing session. For example, one writer who was asked to write about a woman's role for a hostile audience, said: "If an audience were hostile the worst thing to do would be to defend yourself--so I would try to humor them--to make them--uh--more sympathetic maybe . . . ." A second writer assigned this same topic said: "I'm trying to decide whether I want to convince my audience of something specific about--uh--for instance the Equal Rights Amendment or whether something general about women should have the same rights as men--and I also need to decide if I want to actively convince my audience or simply state my point of view . . . ." A few lines later she decides: "I'll try to convince them of what it's like to--not to have certain rights . . . ." A third writer said, "I'm not really trying to persuade these people of anything, I'm simply being descriptive--I'm saying this is the way the world is . . . ."

Goals enter into the model at several places. First, the

goal-setting part of the planning process (see Figure 3-2) uses information from the task environment about the rhetorical situation and information from the writer's long-term memory about the topic and the audience to establish goals for the essay. Examples of such goals are seen in one writer's attempt to make her audience more sympathetic to a point of view and another writer's recognition that her essay for 10-year-olds must be made "very interesting."

Second, the monitor (see Figures 3-3 and 3-4) sets goals for carrying out writing processes. Such goals are reflected in statements such as, "Let's organize this mess," and "OK, let's get it down on paper."

2. Writing is hierarchically organized. When writers have identified their major goals, e.g., the particular aspect of the topic they want to discuss and their general approach to the audience, they frequently identify subgoals on the route to these major goals. Indeed, the subgoals may in turn have their own subgoals. A writer who had as his main goal to write about the "worries" of a particular group set up subgoals to write about the subtopics "the political issue" and "the philosophical issue." Under each of the subtopics he specified a list of three or four sub-subtopics. Thus, his major goal was expanded into a hierarchy of subgoals.

In the same way, the writer who said that he was "simply being descriptive" elaborated his goal as follows: "I think what I really want is to present maybe one [point] with a lot of

illustrations." He then went on to state the point and to develop a list of eight illustrations. In many cases, then, writers tell us in their "thinking aloud" protocols that their goals are hierarchically structured. Even if the writers didn't tell us explicitly though, there would still be plenty of evidence that writing processes are hierarchically organized. For example, many writers start the writing session with a period of planning in which they try to develop an outline to write from. To do this they may first try to generate ideas freely. When they feel they have enough ideas, they try to organize them into an outline. Generating and organizing are part of planning, and planning in turn is part of writing. Clearly these processes are hierarchically organized.

The model reflects the hierarchical organization of writing processes in two ways. First, the structure of processes in the model is intended to match the hierarchical structure of processes observed in writers. Second, operators within the ORGANIZE process allow the model to construct a hierarchical arrangement of goals.

3. Priority interrupts. Editing appears to take precedence over all other writing processes in the sense that editing may interrupt the other processes at any time. The generating process appears to be second in order of precedence since it interrupts any process except editing. Here are two examples of edits (underlined) which interrupt the writer while he is generating new ideas: "The problem is to make the uses more general and acceptable--that's the wrong word--I mean important

seeming"; "Basically the idea is that if one has a special marker in a building that--which-- means stop . . . ."

Interrupts by the editing process often appear quite abruptly. The writer no sooner has the wrong word out than the editing process leaps on it in the middle of a sentence and changes it. Interrupts by the generating process typically wait for the end of a sentence. However, they also appear rather abruptly. For example, while one writer was busily generating sentences according to his writing plan, he unexpectedly said, "possibility of a pleasantry, I suppose, at that point . . . ."

The mechanism for priority interrupts in the model is located in the monitor (see Figure 3-3). The first two rules in the monitor control editing and idea generation. The fact that these two rules come before the goal setting rules (3-6) gives these processes priority over all others.

4. Recursive processes. The term "recursive" is used here in the mathematical sense. A recursive process is one which can contain itself as a part. Perhaps the best way to make this term clear is to start by discussing recursive definitions and to proceed by analogy to recursive processes.

A term is said to be defined recursively when its definition contains the term being defined as a part. At first glance, this situation may seem to involve an unacceptable circularity, but as we will see, everything works out all right. Let's take an example from linguistics.

Consider the following (incomplete) definition of a sentence:

Sentence = noun phrase + predicate, or

sentence + "and" + sentence.

This is a perfectly workable definition even though the term being defined appears in the definition. Consider the problem of deciding whether or not the following string of words is a sentence:

"Frank has warts and Betty has hiccoughs."

Since the string doesn't have the form "noun phrase + predicate," we test to see if it has the form "sentence + 'and' + sentence." To do this, we have to show that the strings before the "and" and after the "and" are sentences. They turn out to be, since both have the form "noun phrase + predicate."

Just as the idea of a recursive definition contains no intractable circularity, neither does the idea that a recursive process can contain itself as a part contain any intractable circularity. To illustrate a recursive process, we will consider the Wendy protocol. In her first draft, Wendy wrote sentence 1 of the final draft and then followed it directly by sentence 7 of the final draft. When she was editing (a part of the writing process), Wendy decided that readers would have trouble with the transition between sentences 1 and 7. As a result she called on the whole writing process to insert a small essay inside her larger essay. The whole writing process then was used as part of editing, and thus as a part of itself.

In the model, the mechanism underlying recursion is hidden in the fine structure of the editing process. We believe that when the editing process identifies a major fault in the text, e.g., lack of context or poor organization, it may employ the whole writing process in the effort to fix the fault.

5. Dynamic modification of goals. When writers choose goals, they are by no means stuck with them. When a goal is difficult to meet, the writer can respond to the difficulty by modifying or abandoning the goal. Consider, for example, the writer who was assigned the task of writing about "abortion: pro and con, for a hostile audience." Early in the session, she decided to include as one of the "pro" topics the point that "a woman should have the right to limit the size of her family." About half-way through the session, she came back to this point and re-evaluated it as follows: "a woman should have the right to limit the size of her family--um--and I think I'm not going to mention that-- because that is not a view that is shared by the audience."

The writer mentioned earlier who was considering "a pleasantry" explored the issue in some detail, decided it wouldn't work well, and abandoned it. This same writer had established goals at various times in the session to write about the issues "individual freedom," "the impact of technology," and "attitudes toward scientific analysis." After considerable work, he discovered relations among the three and tied them together under a single heading as "the philosophical issue." Thus, three independent objectives were modified to become subgoals of a

single higher level goal.

As yet, the model has no mechanism to account for the modification of goals. We assume that the mechanism must reside in the goal setting processes and that it must use information about processing failures fed back to it by the translating and organizing processes. As yet we don't have sufficient data to specify how the mechanism works.

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